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Two Essays on Managerial Risk-Seeking Activities and Compensation Contracts

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Two Essays on Managerial Risk-Seeking Activities and Compensation Contracts

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Dedicated to my dear wife Bo Gyong and to my son Andrew.

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Two Essays on Managerial Risk-Seeking Activities and Compensation Contracts

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This dissertation examines how the structures of compensation for executives and directors are affected by the possibility that managers can influence the risk of a firm's cash flows. In chapter 1, I consider a moral hazard model which shows that a strong pay-for-performance sensitivity in managerial compensation may deteriorate shareholder value when shareholders cannot monitor managerial risk-seeking activities. Intuitively, while high-powered managerial compensation provides the manager with incentives to increase the firm's value by exerting effort, it also creates managerial incentive to engage in (unproductive) risk-seeking activities. To test this prediction, I consider a regulatory change that makes it more difficult for managers to conceal information about the (speculative) use of derivative instruments. Specifically, I examine how the structures of compensation for managers and other executives are affected by the adoption of a new accounting standard, the Statement of Financial Accounting Standard No. 133 *Accounting for Derivative Instruments*

and Hedging Activities ("FAS 133") which mandates the fair value accounting for derivative holdings. Consistent with the model prediction, I find that relative to other firms, *derivative users* (firms that traded derivatives before adopting FAS 133) increase the pay-for-performance sensitivity of CEO/CFO compensation.

In Chapter 2, I extend the model by incorporating the realistic features that shareholders delegate to the (self-interested) board the tasks of monitoring managers and of setting their compensation contracts. My analysis shows that while high-powered board compensation induces the board to monitor the firm and to properly design managerial compensation, it also provides the board with incentives to misreport managerial risk-seeking activities and to engage in collusive behavior with the manager at the expense of shareholders. From these trade-offs, I develop a number of testable hypotheses and take them to the data. Consistent with the model predictions, I find that firms in which (i) managerial risk-seeking activities are more likely to occur (e.g., high R&D firms or banks) and (ii) board monitoring costs are likely to be lower (e.g., firms that have non-officer blockholders on the board) show weaker pay-for-performance sensitivity of board compensation and stronger pay-for-performance sensitivity of CEO compensation.

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Chapter 1

Managerial Incentives, Moral Hazard and Risk Management

1.1 Introduction

Since the seminal work of Jensen and Meckling (1976), economists have proposed a number of mechanisms that can alleviate the agency conflicts between shareholders and managers. Among these mechanisms, managerial compensation has been considered a key instrument to mitigate the managerial agency conflicts (see Frydman and Jenter 2010 for recent surveys of the literature). In particular, the literature focuses on the sensitivity of managerial pay to firm value (i.e., pay-for-performance sensitivity) and suggests that stronger pay-for-performance sensitivity helps to address the incentive misalignment between shareholders and managers.[1]

This paper examines the design of optimal managerial compensation in a setting in which corporate hedging activities are made by a manager who does not fully internalize the effect of his actions on shareholder value. My analysis

[1]While, strictly speaking, monotonicity is not implied by a general model (e.g., Hölmstrom 1979), the literature identifies several conditions in which increasing pay-for-performance emerges as part of the optimal compensation package (e.g., Hölmstrom and Milgrom 1987). See also Jensen and Murphy (1990) who suggest that the pay-for-performance sensitivity of CEO compensation may be too weak in practice.

shows that strong pay-for-performance sensitivity may induce the manager to make suboptimal hedging choices and thus deteriorate shareholder value. More specifically, the main trade-off in the design of managerial compensation is as follows: While a strong pay-for-performance sensitivity provides the manager with incentives to increase the firm's value by exerting costly effort, it also creates perverse incentives to engage in (unproductive) risk-seeking activities.

To formally analyze the incentive provision problem, I consider a firm in which a risk-neutral manager with limited liability performs two hidden actions: (i) a costly managerial action (e.g., operational choices that require managerial effort) that enhances the firm's value without affecting the risk of its cash flows and (ii) a costless managerial action (e.g., a trade of financial instruments) that influences the risk of the firm's cash flows without affecting the firm's value.[2] In such a setting, I examine the structure of managerial compensation that provides proper incentives to maximize shareholder value.

My analysis shows that the structure of optimal managerial compensation is fundamentally affected by the possibility of financial speculation. Specifically, high pay-for-performance compensation is necessary to induce managerial effort but it also provides incentives to take speculative positions in financial instruments. Intuitively, while high pay-for-performance compensation entices the manager to seek substantial profits from financial speculation, the manager's limited liability helps mitigate the consequences of substantial

[2] For simplicity, I assume that financial instruments are fairly valued in the market and that the manager does not have private information about these instruments.

losses from the speculation. Therefore, my analysis predicts that the pay-for-performance sensitivity of managerial compensation increases as it becomes more difficult for the manager to conceal information about the (speculative) use of financial instruments.[3]

In the second part of the paper I take this prediction to the data. Specifically, I examine how the structure of managerial compensation is affected by a regulatory change which mandates that firms disclose more information about their risk exposure to derivative markets. In 1998, the Financial Accounting Standards Board ("FASB") issued a new accounting standard for trading financial derivatives, namely, the Statement of Financial Accounting Standards No. 133 *Accounting for Derivative Instruments and Hedging Activities* ("FAS 133"). Under this new accounting standard, firms must recognize (unrealized) gains/losses from changes in the fair value of derivative holdings but they can offset the gains/losses from qualified hedging instruments by recognizing the hedged items at fair value.[4] Thus, FAS 133 requires that the financial statement disclose comprehensive information about the firm's risk exposure to derivative instruments.

To examine the effect of this regulatory change on the structure of managerial compensation, I use a difference-in-differences model. Specifically, I identify firms that traded derivatives before the adoption of FAS 133 ("*users*")

[3]In contrast, DeMarzo and Duffie (1995) predict that the disclosure of information about corporate hedging may reduce the managerial incentive to engage in hedging activities.

[4]FAS 133 offers three categories of hedging instruments which requires different qualification standards. Refer to section 1.4.1 for details.

and investigate whether they tend to increase the pay-for-performance sensitivity of managerial compensation more than other firms ("*non-users*") after the adoption of FAS 133. The premise of this empirical setting is that *non-users* are not affected by the change in the accounting standard for derivative instruments while it becomes harder for the managers of *users* to hide information about their speculative derivatives trading.

This natural experiment setting has several advantages. First, the adoption of FAS 133 provides an exogenous shock which helps to address endogeneity problems that typically arise when searching for empirical determinants of the compensation structure since the new accounting standard does not directly affect the compensation structure.[5] Furthermore, since FAS 133 affects only the speculative use of derivatives, this empirical setting helps to solve the problems of distinguishing speculative trades from hedging activities in the data.[6]

Following Gormley et al. (2013), I measure the pay-for-performance sensitivity of CEO compensation by the increment in the fair value of stock and option grants for a 1% increase in the stock price.[7] To capture the managerial

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[5]Previous studies (e.g., Bertrand et al. 2004) proposed certain cases in which estimates of the difference-in-differences model are biased. These issues will be discussed in section 1.5.

[6]To identify the purpose of derivative trades, previous studies focus on certain industries, e.g., the gold mining industry or the airline industry, in which the relevant data is available. See, e.g., Tufano (1996), Adam and Fernando (2006) and Rampini et al. (2014) among others.

[7]To check the robustness of the results, I also consider some alternative compensation measures in section 1.5.4.

incentives to increase the firm's cash flow risks, I also measure the convexity of CEO compensation by the increment in the fair value of option grants for a 1% increase in the stock price volatility. Consistent with the model prediction, I find that after the adoption of FAS 133, *users* increase the pay-for-performance sensitivity and the convexity of CEO compensation more than *non-users*. All else being equal, for each 1% increase in the stock price (resp., the stock price volatility), CEOs of *users* earn $24,370 (resp., $21,310) more than other CEOs after the adoption of FAS 133 while the two groups of firms do not show a significant difference in these CEO compensation measures before the adoption of FAS 133.

As a robustness check, I examine how the new accounting standard affects the pay-for-performance sensitivity and the convexity of other executives' and directors' compensation. I find that *users* increase only the pay-for-performance sensitivity and the convexity of CFO compensation more than other firms after the adoption of FAS 133. This result indicates that the new accounting standard affects the compensation of executives (i.e., CEOs and CFOs) who actually oversee the use of derivative instruments. I also find that the effect of FAS 133 on the compensation structure is economically and statistically stronger in firms which used derivative instruments more intensively before adopting FAS 133. Finally, I conduct several falsification tests to verify that the compensation measures of *users* and *nonusers* have a common trend before adopting FAS 133.

This study is related to several branches of the managerial compensation literature. First, my empirical findings offer new evidence on the determinants of managerial compensation. To explain cross-sectional differences in managerial pay-for-performance sensitivity, previous studies propose a number of empirical factors that include a firm's cash flow risks, leverage, growth opportunities, institutional ownership and the degree of business focus.[8] This paper proposes that the managerial ability to conceal information about corporate hedging activities is a key determinant of managerial pay-for-performance sensitivity. I also find empirical evidence that supports this prediction.

Second, my model contributes to the theoretical literature that examines the design of optimal managerial compensation. While most studies focus exclusively on the provision of managerial incentives to exert (costly) effort that increases shareholders value, I also consider the incentives to engage in risk-seeking activities which increase the firm's cash-flow risks. An important exception is He and Xiong (2013) who theoretically show that a strong pay-for-performance sensitivity of compensation for fund managers may induce them to deteriorate the fund's value by seeking tail risks (i.e., unprofitable and negatively skewed investments). While my model analysis also sheds light on the risk-taking incentives created by a strong pay-for-performance sensitivity, it shows that even managerial risk-seeking activities which do not directly affect the firm's value nor the marginal productivity of managerial effort can deteriorate the firm's value by making the (realized) cash flows of the firm less

[8]See, e.g., Himmelberg et al. (1999), Hartzell and Starks (2003), Coles et al. (2006), Low (2009) and Gormley et al. (2013) among many others.

informative about the manager's effort choice, therefore reducing the managerial effort incentive provided by the pay-for-performance compensation.

Finally this paper also contributes to the literature on the effectiveness of fair value accounting standards. DeMarzo and Duffie (1995) examine the effect of fair value accounting on corporate hedging activities within a manager's career concern setting, and they predict that fair value accounting can reduce the managerial incentive to hedge firm's cash flow risks. In contrast, I analyze this issue within the principal-agent framework and show that fair value accounting can facilitate corporate hedging activities by making it harder for managers to misreport speculative trades as hedging activities. Consistent with my prediction, previous studies (e.g., Zhang 2009) find that the adoption of FAS 133 decreases the cash flow volatility of firms that used derivative instruments before adopting FAS 133. This paper also contributes to the literature by providing empirical evidence that fair value accounting allows firms to increase the sensitivity of managerial compensation to the firm's value.

The paper is organized as follows. Section 1.2 introduces the model set-up and Section 1.3 provides the model analysis. Section 1.4 discusses the empirical setting and data and Section 1.5 reports the results. Section 1.6 concludes.

1.2 The Model

I consider an all-equity firm that operates in a risk-neutral economy in which the market rate of return is normalized to zero.

1.2.1 Firm project and managerial actions

The firm's assets consist in a project that yields a random terminal cash flow $\tilde{r} = \{r^d, r^m, r^u\}$, where $r^m = \frac{r^u + r^d}{2}$ and $0 < r^d < r^u$. The probability distribution of $\tilde{r}$ is affected by two managerial actions e and Δ as follows:

$$\tilde{r} = \begin{cases} r^u & \text{with prob. } \frac{1}{3} + e + \Delta \\ r^m & \text{with prob. } \frac{1}{3} - 2\Delta \\ r^d & \text{with prob. } \frac{1}{3} - e + \Delta, \end{cases} . \tag{1.1}$$

I refer to $e \in [0, 1]$ as "managerial effort" which is privately *costly* to the manager

$$c(e) = \frac{1}{2}\gamma_m e^2. \tag{1.2}$$

As shown in (1.1), relative to $e = 0$ which is the minimum effort choice, $e > 0$ increases the likelihood of r^u at the expense of r^d and thus increases the firm's expected cash flow by $\theta(r^u - r^d)e$. Furthermore, I refer to $\Delta \in \{\Delta_0, \Delta_s\}$ (where $0 = \Delta_0 < \Delta_s < \frac{1}{6}$) as the managerial "risk choice" which is *costless* to the manager. Relative to Δ_0, the risk choice Δ_s is a mean-preserving spread which increases the likelihood of extreme cash flows r^u and r^d at the expense of the moderate cash flow r^m.[9]

[9] The possibility of costless risk-management choices allows me to consider a particularly relevant case, namely, the case in which a manager can make financial transactions on behalf of their firms. Net of transaction costs, financial transactions are ex-ante zero NPV transactions that affect the riskness of a firm's cash flows risk without altering the firm's value. In this sense, the analysis can be interpreted as an analysis of the provision of managerial and board incentives when a manager can engage in financial speculation.

1.2.2 Managerial agency problems and contracts

In this setting I consider the managerial agency problems by assuming that shareholders do not observe the managerial choices of e and Δ. Thus, shareholders can influence the managerial choices only via the design of managerial compensation. Formally, shareholders write the managerial compensation contract w as a function of the firm's cash flow $\tilde{r}$. For convenience, I rewrite the managerial compensation $w(\tilde{r})$ as:

$$w(\tilde{r}) = (w_u, w_m, w_d)\,, \tag{1.3}$$

where w^i $(i = u, m, d)$ corresponds to the managerial pay for the realized cash flow r^i.

The sequence of events unfolds as follows: At $t = 0$, shareholders offer $w(\tilde{r})$ to the manager. At $t = 1$, the manager chooses e and Δ. At $t = 2$, the firm's cash flow $\tilde{r}$ is realized and contracts are enforced.

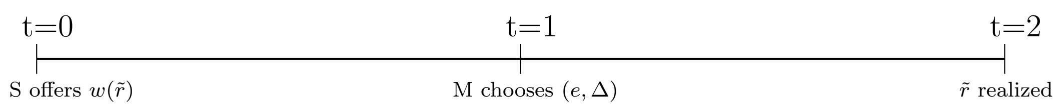

Figure 1. Sequence of events

1.3 Model Analysis

To better understand the economics demonstrated by the model, I first consider the case in which shareholders (i) observe (and write w upon) the managerial choice of Δ but (ii) do not observe the managerial choice of e. I then consider the case in which shareholders do not observe either managerial choice.

1.3.1 Observable Δ

Consider the case in which shareholders observe the manager's choice of Δ but not the choice of e. This case is equivalent to the case in which shareholders choose Δ on their own since the choice of Δ is costless to the manager. Therefore, the shareholders' problem can be written as follows:

$$\max_{w_m, e^*, \Delta} \; (\frac{1}{3} + e^* + \Delta)(r^u - w_u) + (\frac{1}{3} - 2\Delta)(r^m - w_m) + (\frac{1}{3} - e^* + \Delta)(r^d - w_d) \quad (1.4)$$

subject to

$$e^* = \underset{e}{\text{argmax}}(\frac{1}{3} + e + \Delta)w_u + (\frac{1}{3} - 2\Delta)w_m + (\frac{1}{3} - e + \Delta)w_d - \frac{1}{2}\gamma_m e^2 \quad (1.4.1)$$

$$w_u, w_m, w_d \geq 0 \quad (1.4.2)$$

Constraint (1.4.1) corresponds to the managerial incentive compatibility constraint relative to the choice of e while (1.4.2) ensures that the manager is subject to limited liability. The use of first order approach is valid in this setting since the manager's maximization problem in (1.4.1) has a unique global maximum with respect to e.[10] The following lemma, which is immediate from the first order condition of (1.4.1), states the manager's effort choice:

Lemma 1.3.1. *A manager who receives a compensation contract $w(\tilde{r})$ exerts*

[10] See Grossman and Hart (1983) for the regularity conditions of the first order approach.

effort

$$e(w) = \frac{w_u - w_d}{\gamma_m}. \tag{1.5}$$

Lemma 1.3.1 shows that the manager chooses higher effort as (i) the difference $w_u - w_d$ increases and (ii) the effort is less costly to the manager (γ_m decreases). By (1.5), I can simplify the shareholders' problem by substituting $e(w) = \frac{w_u - w_d}{\gamma_m}$ into e^* in (1.4). Proposition 1.3.2 summarizes the solution of the shareholders' problem:

Proposition 1.3.2. *When shareholders observe the manager's choice of Δ but not the choice of e, they force the manager to choose $\Delta = \Delta_0$ and design the managerial compensation as follows:*

$$w^*(\tilde{r}) = \left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6}, 0, 0 \right)$$

Proposition 1.3.2 shows that shareholders do not allow the manager to choose Δ_s, which would decrease shareholder value by increasing the expected value of managerial compensation without increasing the expected value of the project. Proposition 1.3.2 also states that the optimal managerial compensation contract pays only for the realization of $\tilde{r} = r^u$. This result is immediate from lemma 1.3.1, which states that larger wedge between w_u and w_d (i.e., the managerial pay for r^u and r^d, respectively) provides the manager with incentives to exert more effort.

1.3.2 Unobservable Δ

In this section, I consider the case in which shareholders do not observe the managerial choices of effort and risk (i.e., e and Δ). In this case, shareholders design managerial compensation by taking into account the effect of compensation contracts on the manager's choice of e and Δ. Formally, the shareholders' problem can be written as:

$$\max_{w_m, e^*, \Delta^*} \quad (\frac{1}{3} + e^* + \Delta^*)(r^u - w_u) + (\frac{1}{3} - 2\Delta^*)(r^m - w_m) + (\frac{1}{3} - e^* + \Delta^*)(r^d - w_d) \tag{1.6}$$

subject to

$$(e^*, \Delta^*) = \underset{e,\Delta}{\text{argmax}}(\frac{1}{3} + e + \Delta)w_u + (\frac{1}{3} - 2\Delta)w_m + (\frac{1}{3} - e + \Delta)w_d - \frac{1}{2}\gamma_m e^2 \tag{1.6.1}$$

$$w_u, w_m, w_d > 0 \tag{1.6.2}$$

Constraint (1.6.1) corresponds to the incentive compatibility constraints relative to the manager's choice of e and Δ while (1.6.2) ensures that the manager is subject to limited liability. The use of the first order approach is still valid in this setting since the manager's maximization problem in (1.6.1) has a unique global maximum with respect to e and Δ. The following lemma describes the manager's effort and risk choices which solve the manager's optimization problem in (1.6.1):

Lemma 1.3.3. *When shareholders do not observe the manager's choice of e and Δ, the managerial compensation contract $w(\tilde{r}) = (w_u, w_m, w_d)$ induces the manager to make an effort choice and risk choice as:*

$$e(w) = \frac{w_u - w_d}{\gamma_m}. \tag{1.7}$$

and

$$\Delta(w) = \begin{cases} \Delta_s & \textit{if } w_u + w_d > 2w_m \\ \Delta_0 & \textit{otherwise.} \end{cases} \tag{1.8}$$

Lemma 1.3.3 shows that the manager exerts more effort as (i) the managerial compensation exhibits a higher wedge between w_u and w_d (i.e., the managerial pay for r^u and r^d, respectively) and (ii) exerting effort is less costly to the manager (i.e., γ_m is lower). Relative to the manager's choice of Δ, lemma 1.3.3 states that the manager chooses the risky choice Δ_s if the average pay for r^u and r^d is higher than the pay for r^m (i.e., $w_u + w_d > 2w_m$). From these observations, I refer to $w_u - w_d$ (which captures the size of incentives relative to managerial effort choice) as a *pay-for-performance sensitivity* of a managerial compensation contract $w(\tilde{r}) = (w_u, w_m, w_d)$ and refer to $w_u + w_d - 2w_m$ (which captures the incentives relative to the managerial risk choice) as a convexity.

To simplify (1.6), I substitute (1.7) and (1.8) into e^* and Δ^*, respectively. By solving the problem, I find the optimal compensation contract characterized as follows:

Proposition 1.3.4. *When shareholders do not observe the manager's choice of e and Δ, they design the managerial compensation as follows:*

$$w^*(\tilde{r}) = (w_u^*, w_m^*, w_d^*) = \left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{2} \left[\frac{1}{3} + \Delta_s \right], 0, 0 \right)$$

Proposition 1.3.4 shows that the optimal managerial compensation exhibits a strictly positive convexity, i.e., $w_u^* + w_d^* - 2w_m^* > 0$ and, thus, induces the manager to choose Δ_s. Intuitively, shareholders face the following trade-off in the design of managerial compensation: While the managerial pay for r^m (i.e., setting $w_m > 0$) deters the managerial choice of Δ_s, it increases the expected compensation without providing the managerial incentive to exert effort. Under the assumption that $\Delta_s < \frac{1}{6}$ which is the regularity condition to construct a valid probability structure, it is too costly for shareholders to discourage managerial choice of Δ_s by offering a linear compensation (i.e., setting $w_m = \frac{w_u}{2}$).[11]

To examine how the possibility of (unobservable) managerial risk-seeking activities affects the compensation structure, I compare the managerial compensation contract characterized in proposition 1.3.2 with the one described in proposition 1.3.4. While both compensation contracts have the same form (i.e., rewarding only for r^u), they differ on the level of the pay-for-performance sensitivity (i.e., $w_u^* - w_d^*$) and the convexity (i.e., $w_u^* + w_d^* - 2w_m^*$). Specifically:

Proposition 1.3.5. *Optimal managerial compensation exhibits lower pay-for-performance sensitivity and lower convexity when shareholders do not observe the manager's choice of* Δ.

Proposition 1.3.5 shows that the possibility of managerial risk-seeking activities decreases the efficiency of managerial pay-for-performance compensation. Intuitively, while strong sensitivity of managerial compensation to the

[11] This assumption can be relaxed by changing the probability of $\tilde{r}$ at $e = 0$ and $\Delta = \Delta_0 = 0$. As discussed below, however, the key intuition still hold in the relaxed settings.

firm's cash flows is necessary to induce managerial effort, the corresponding convexity of managerial compensation also creates an incentive to increase the firm's cash flow risks since the manager who is subject to the limited liability does not fully internalize the consequence of negative cash flows. This perverse incentive reduces the gain that shareholders derive from offering a high managerial pay-for-performance sensitivity. In the next section, I take this prediction into the data and test whether the pay-for-performance sensitivity and the convexity of managerial compensation increases after a regulatory change that allows shareholders to have access to the information about managerial risk-seeking activities.

1.4 Empirical analysis

1.4.1 Statement of Financial Accounting Standard 133

In 1998, the Financial Accounting Standard Board ("FASB") issued the Statement of Financial Accounting Standards No. 133. *Accounting for Derivative Instruments and Hedging Activities* ("FAS 133").[12] Before the enactment of FAS 133, the accounting treatment for derivative holdings was ruled by the Statement of Financial Accounting Standards No. 52 *Foreign Currency Translation* and No. 80 *Accounting for Futures Contracts*. These standards required firms to report the purpose of derivative transactions and to use different accounting treatments depending on the purpose. Specifically,

[12]The effective date of FAS 133 was initially June 15, 1999 but by the request of firms, it was delayed until June 15, 2000.

under these standards firms should recognize the (unrealized) gain/loss from fair value changes in the derivatives held for investment purposes while they could recognize hedging instruments at the historical costs.

After some corporations reported large and unexpected derivative losses in 1990s, the Security and Exchange Committee urged the FASB to develop a new accounting standard which requires that financial statements provide adequate information about the firm's use of derivative products.[13] In response to this requests, the FASB issued FAS 133 which eliminates the possibility of historical cost accounting for derivative instruments. Specifically, FAS 133 states that (i) firms must recognize their derivative holdings at fair value and (ii) for those qualified as hedging instruments, firms can also recognize the corresponding hedged items at fair value.[14] Thus, FAS 133 ensures that the financial statement discloses comprehensive information about the purpose of each derivative holding.

1.4.2 Empirical setting

My model analysis predicts that after adopting FAS 133 firms would increase the pay-for-performance sensitivity and the convexity of CEO compensation. More specifically, since FAS 133 is effective exclusively to the firms which use derivative instruments ("*users*"), I hypothesize that, relative to other firms, *users* increase the pay-for-performance sensitivity and the convex-

[13] See *Background information and basic for conclusions* of FAS 133 for more details.

[14] The derivative holdings qualified as cash flow hedge is not subject to the fair value accounting until the gains/losses from hedged items are realized.

ity of CEO compensation after adopting FAS 133.[15] To test this hypothesis, I use the difference-in-differences model specified as follows:

$$y_{i,t} = \beta_0 + \beta_1 FAS133_t + \beta_2 User_i + \beta_3 FAS133_t \times User_i + X_{i,t}\Gamma + \epsilon_{i,t}, \quad (1.9)$$

where $y_{i,t}$ is a measure of CEO compensation, $X_{i,t}$ is control variables, *FAS133* is an indicator of the fiscal years after the adoption of FAS 133 (i.e., 1 for fiscal years 1999–2001 and 0 for 1996–1997) and *User* is an indicator of derivative users before the adoption of FAS 133 for firm i and year t.[16]

As controls I include a number of determinants of pay-for-performance compensation proposed by previous studies (e.g., Yermack 1995, Guay 1999a and Coles et al. 2006). First I consider the effect of a firm's past performance i.e., past return on firm assets and past stock returns.[17] Specifically, I include lagged return on assets and annual stock returns (*ROA* and *Return*, respectively). Second, I include the KZ index modified by Baker et al. (2003)and the presence of long-term debt indicator (*KZ4* and *LTD*, respectively) as proxies for the level of a firm's financial constraints.[18] Yermack

[15]See, e.g., Zhang (2009) for other studies that consider the differentiated effect of FAS 133 on *users* and *non-users*.

[16]The FASB required firms to adopt FAS 133 no later than fiscal year 2001 (originally 2000) but strongly suggested to adoption as early as possible. While many firms adopted FAS 133 since 2001 (Zhang 2009), I set the post-FAS 133 period as 1999–2001 to consider the possible early adoptions. The main results are robust to the adjustments of post-FAS 133 period.

[17]Previous studies suggest contrasting predictions relative to the effect of the past performance on the level of pay-for-performance compensation. See, e.g., Core and Guay (2001) for the details.

[18]In unreported robustness checks I also consider cash flow shortfalls (i.e., [common and preferred dividends+cash flow used in investing activities-cash flow from operations]/total

(1995) reports that to defer the cash payout financially constrained firms tend to award managers stock options (which, as described below, I use as a measure of pay-for-performance compensation) in lieu of cash compensation.

Third, I control for tax effects on compensation by including an operating loss dummy variable *Loss*. Intuitively, firms that have net operating loss carryforwards expect higher future tax returns and thus desire to defer the compensation expense by awarding stock options. Fourth, I consider firm size (i.e., *Ln(asset)* and *Ln(sale)*), R&D intensity (*R&D*) and the market-to-book value ratio (*MB*) to control for the effect of business characteristics on the compensation structure.

Finally, I control for CEO and board characteristics relative to the CEO's influence on the board to capture situations in which CEOs can influence boards to design CEO pay with cash compensation rather than pay-for-performance compensation (Chhaochharia and Grinstein 2009). Specifically, I consider the board independence, the CEO's tenure and the CEO-chairman duality (i.e., *IND*, *Ln(tenure)* and *Dual*, respectively). I also include a new CEO indicator (*NCEO*) to control for the irregular compensation practices for incoming CEOs (Fee and Hadlock 2003).[19] The details of each variable are available in Table 1.1.

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assets) which is also widely used as a proxy for the degree of financial constraints (e.g., Yermack 1995).

[19] As a robustness check, I estimate the regression by excluding the firms that change their CEOs during the sample period and find that the results are consistent.

1.4.3 Data

During the period 1996–2001, I first obtain the CEO characteristics (i.e, compensation, tenure and CEO/Chair duality) from Execucomp, the financial information from Compustat and the board characteristics from RiskMetrics.[20] For the firms that are available in these datasets, I collect the information about their use of derivatives from 10-K filings in 1996–1997 (i.e., the period before the issuance of FAS 133). Specifically, following Guay (1999b) and Zhang (2009), I search keywords such as *forward contract(s), currency exchange contract(s), foreign exchange contract(s), future(s) contract(s), option(s) contract(s), swap(s), hedging instrument(s), hedge instrument(s), derivative instrument(s)*; and I read the pages that include keywords to verify whether the firm actually used derivatives. After excluding financial firms (SIC 6000–6999) and utilities (SIC 4900–4999), the sample consists of 2905 firm-years of derivative *users* and 1855 firm-years of *non-users*.[21]

Table 1.2 reports the average derivative holdings of *users* relative to their book assets in 1996–97 (Panel A) and the industry clusters of *users* and *non-users* (Panel B). Following the previous literature (e.g., Zhang 2009), I divide derivatives into three categories, namely, "foreign exchange derivatives," "interest rate derivatives" and "commodity derivatives" and define *intensity* as (fiscal year-end derivative holdings/assets). In the calculation of *intensity*,

[20]The FASB requires firms to adopt FAS No. 133 by FY 2001 but strongly suggests earlier adoption.
[21]All nominal variables are deflated by the Consumer Price Index.

I exclude the holdings of "commodity derivatives" since in 10-K filings these derivative instruments are reported as the amount of commodities rather than the dollar value. Panel A shows that 341(resp. 275 and 115) firms trade foreign exchange (resp. interest rate and commodity) derivatives.[22] The holdings of each derivative relative to the book assets decrease when the firm uses other types of derivatives and, in particular, the average holdings of foreign exchange or interest rate derivatives correspond to around 15% of assets.

Panel B presents the top five and bottom five industries (based on the Fama-French 48 industry classification) in terms of the fraction of *users* relative to *non-users*.[23] Specifically, "Beer and Liquor," "Precious Metals," "Food Products," "Aircraft" and "Petroleum and Natural Gas" industries correspond to the top five (i.e., most likely to include *users*) while "Defense," "Personal Services," "Entertainment," "Construction" and "Restaurants, Hotels, Motels" industries correspond to the bottom five. The industry clusters presented in Panel B show that the use of derivative instruments is affected by the business characteristics.

Table 1.3 presents summary statistics of CEO compensation in 1996–1997 (Panel A) and 1998–2001 (Panel B). In both periods derivative users tend to pay the CEO more than non-users do and, in particular, the gap becomes

[22] As shown in Panel B, 508 firms traded derivatives in 1996–1997 but the 16 firms which do not provide holdings of foreign exchange or interest rate derivatives in their 10-K are excluded in Panel A.

[23] To take into account the difference in the sample size of *users* and *non-users*, I normalize the fraction of *users* and *non-users* by the total number of firms in each group.

wider after the issuance of FAS 133. With respect to the equity grants, the value of option grants is larger in *users* while the value of restricted stock grants is similar between the two groups of firms. Specifically, after the issuance of FAS 133, the mean difference in the value of option grants increases from $1.04 mil to $2.06 mil.

To measure the pay-for-performance sensitivity of CEO compensation, I calculate the *Delta* of stock and option grants to the CEO (i.e., the change in the value of stock and option grants for a 1% increase in the stock price). As a proxy for the compensation convexity, I also consider the *Vega* of option grants to the CEO (i.e., the change in the value of option grants for a 1% change in the stock return volatility).[24] Table 1.3 reports that both *Delta* and *Vega* are greater in *users* and the mean difference becomes larger after the issuance of FAS 133. To better illustrate the trend of these compensation measures, in Figure 1.1 I plot the year-medians of *Delta* (Panel A) and *Vega* (Panel B) of CEO compensation in 1996–2001. Figure 1.1 illustrates that both compensation measures have increased during the period. Consistent with Table 1.3, Figure 1.1 shows that the CEO compensation of *users* exhibits higher *Delta* and Vega and also shows that the gaps in both measures become wider after the issuance of FAS 133.

Table 1.4 summarizes firm characteristics used as proxies for the determinants of compensation structure and, in particular, contrasts the character-

[24] I construct *Delta* and *Vega* measures using the methodology of Gormley et al. (2013).

istics of *users* and *non-users* in 1997. Relative to other firms, *users* tend to be larger (i.e., higher *Ln(asset)* and *Ln(sale)*) and financially less constrained (i.e., higher *KZ4*). These firms also have lower growth opportunities (i.e., lower *MB*) and issue more long-term debt (i.e., higher *LTD*). In terms of the CEO-board relationship, users are more likely to exhibit the CEO-Chair duality and to form a board with a majority of independent directors. In the unreported analysis, I confirm that these contrasting features of *users* and *non-users* are observed in the entire sample period (1996–2001).

1.5 Results

1.5.1 Effect of FAS 133 on CEO compensation structure

I estimate the difference-in-differences model in (1.9) to examine how the structure of CEO compensation is affected by the regulatory change that mandates firms to disclose information about their (speculative) use of derivatives. Table 1.5 shows that after adopting FAS 133, *users* increase *Delta* of CEO compensation more than *non-users*.[25] Consistent with the summary statistics in Table 1.3, the estimation without controls (column 1) reports that users grant higher *Delta* in the pre-FAS133 period and the mean difference between two groups increases after adopting the new accounting standard. In the estimation with controls (column 3), however, it turns out that the mean

[25] In all reported estimations, the standard errors are adjusted to industry clusters. As a robustness check, I also use the standard errors adjusted to firm clusters and find similar statistical inferences.

difference is statistically significant only in the post-FAS 133 period.[26] Specifically, for a 1% increase in the stock price, *user* firm CEOs earn $24,370 more than other CEOs after adopting the new accounting standard. The result is robust to controlling for firm fixed effects (column 5) and industry-year fixed effects (column 7). To control for the possible effect of CEO turnover on the result, I also consider a sample excluding firms that experienced a CEO turnover in 1996–2001 and find the robustness of the result (columns 6 and 8).

Table 1.6 presents the estimation results with respect to the *Vega* of CEO compensation. In the estimation with controls (column 3), I find that users grant more convex CEO compensation than other firms only in the post-FAS133 period. Specifically, for a 1% increase in the stock price volatility, *user* firm CEOs earn $21,310 more than other CEOs after adopting the new accounting standard. As in *Delta* regressions, I also check the robustness of results by performing the estimation with firm fixed effects (column 5) and industry-year fixed effects (column 7) and by excluding firms that experience CEO turnovers (columns 6 and 8). Overall the estimation results show that, relative to other firms, *users* award their CEO compensation with a stronger pay-for-performance sensitivity and convexity after adopting the new accounting standard which makes it more difficult for the CEO to conceal their (speculative) use of derivatives from shareholders.

[26]To control for the change in total compensation, I also include *ln*(salary+bonus) as a control variable in an unreported estimation and find that the results are robust.

1.5.2 Effect of FAS 133 on the compensation structure for other executives and directors

While my model analysis in section 1.3 focuses on the structure of optimal managerial compensation, its key insight can be extended to the design of compensation for other employees. In particular, I predict that the adoption of FAS 133 will increase the pay-for-performance sensitivity and the convexity of CFO compensation rather than other executives' or directors' compensation since, besides the CEO, the CFO manages the use of derivative instruments in practice.[27] To test these predictions, I estimate the difference-in-differences model in (1.9) with respect to the *Delta* and *Vega* of CFO compensation, non-CEO/CFO executive compensation and outside director compensation.[28] This analysis can be used as placebo tests on the validity of the natural experiment setting since the differentiated effect of the regulatory change on the compensation for CEO/CFO and other executives (and directors) shows that the heterogeneous trends of compensation structure between *users* and *non-users* are not driven by (unobservable) characteristics.

Table 1.7 reports the estimation results with respect to the *Delta* (column 1-3) and *Vega* (column 4-6) of CFO compensation. In all estimations, I include the controls considered in Table 1.5 and 1.6. Columns 1 and 4 show

[27]For instance, Brown (2001) reports that HDG Inc. delegates the authority of managing foreign exchange risks to the Foreign Exchange Management Committee chaired by the CFO.

[28]Following Jiang et al. (2010), I identify the CFO by searching keywords such as *CFO, chief financial officer, treasurer, controller, finance* and *vice president-finance* in the annual title of executives (i.e., "titleann" in Execucomp).

that *users* increase *Delta* and *Vega* more than *non-users* after adopting FAS 133. Specifically, for each 1% increase in the stock price (resp. the stock price volatility), CFOs of *users* earn around \$1,900 (resp., \$2,400) more than CFOs of *non-users* after adopting FAS 133. The results are robust when controlling for firm fixed (columns 2–3 and 5–6) and industry-year fixed effects (columns 3 and 6).

Table 1.8 presents the estimation results with respect to the compensation measures of other executives (columns 1–4) and directors (columns 5–8). After controlling for controls considered in the previous estimations, I cannot reject the null hypothesis that FAS 133 has an equal effect on the compensation for other executives and directors of the two cohorts. Relative to the analysis of compensation for the CEO/CFO, the estimators in the analysis of other executives' and directors' compensation may have higher standard errors which can reduce the statistical significance of the estimates. To address this issue, I exclusively consider the compensation for Chief Operating Officers (COO) in an unreported analysis and find that the effect of FAS 133 on their compensation is insignificant. Overall, the estimation results show that the adoption of FAS 133 increases the pay-for-performance sensitivity and convexity of compensation for CEOs and CFOs who are responsible for the use of derivative instruments but it may not affect the structure of other executives' and directors' compensation.

1.5.3 Intensity in the use of derivatives and the effect of FAS 133 on the compensation structure

As a robustness check, I investigate whether the adoption of FAS 133 has a stronger impact on the compensation structure of the firms that have used derivatives more intensively before the issuance of FAS 133. To test this prediction, I use *Intensity*, a measure calculated as the average ratio of "year-end foreign exchange and interest rate derivative holdings/book assets" in 1996 and 1997, and I create two dummy variables: *High* and *Low*, which indicate *users* whose *Intensity* measure is above-median and below-median, respectively. Then, I estimate the difference-in-differences model in (1.9) by replacing the independent variable *User* with *High* or *Low*.

Table 1.9 reports the estimation results for CEO compensation measures (*Delta* and *Vega* in columns 1 and 2, respectively) and CFO compensation measures (*Delta* and *Vega* in columns 3 and 4, respectively). In all estimations, I include controls, firm and year fixed effects.[29] The results show that the effect of FAS 133 on the compensation structure is stronger in *intensive users* (i.e., firms with *Hign*=1). Columns 1 and 3 show that, relative to *non-users*, *intensive users* increase the dollar gains of CEO (resp. CFO) from a 1% increase in the stock price by \$43,800 (resp. \$11,900) after adopting FAS 133. Consistent with these results, columns 2 and 4 present that relative to *non-users*, *intensive users* increase the dollar gains of CEO (resp. CFO) from a 1% increase in the stock price volatility by \$34,400 (resp. \$10,850). On

[29]The results are robust to other sets of fixed-effects considered in Table 1.5.

the other hand, coefficient estimates of the interaction term *FAS133*Low* in columns 1–4 are statistically and economically much weaker than the corresponding estimates of *FAS133*High*. These estimation results show that while both types of *users* increase the pay-for-performance sensitivity and convexity of CEO/CFO compensation more than *non-users* after adopting FAS 133, the magnitude of changes is much stronger in *intensive users*.

1.5.4 Other compensation measures

To check the robustness of the results, I estimate the difference-in-differences model by using alternative pay-for-performance sensitivity measures as dependent variables. First, I consider the ratio of the value of equity grants (i.e., option and/or stock grants) to cash compensation (i.e., salary and bonuses).[30] Table 1.10 shows that, relative to other firms, *users* increase equity grants to their CEO/CFO rather than cash compensation after adopting FAS 133 (column 1–4). These results are consistent with the estimation results in Table 1.5–1.7. Alternately, I also consider the other pay-for-performance sensitivity measure suggested by Yermack (1995), namely, *Ydelta* which is defined as the change in the value of option grants per $1,000 increase in equity value. Table 1.10 shows that, while the effect of FAS 133 on the *Ydelta* of CEO compensation is not statistically significant (column 5), its effect on the *Ydelta* of CFO compensation is both positive and significant (column 6). Specifically,

[30]In estimating the regressions, I use the natural logarithm of (1+equity-to-cash compensation ratio) to adjust the right skewness of the ratio.

the adoption of FAS 133 causes CFO compensation of *users* to increase more than that of other firms by \$0.195 per \$1,000 increase in the market equity value. Consistent with the estimation results in Table 1.8, Table 1.10 also shows that FAS 133 has insignificant effects upon the compensation for other executives (column 7) and directors (column 8).

1.5.5 Falsification tests

While the difference-in-differences model helps to address a number of endogeneity problems, its estimates can be biased if both *users* and *non-users* followed different trends before adopting FAS 133. To mitigate this concern, I conduct falsification tests by assuming that the adoption of FAS 133 was available in earlier years. Specifically, I estimate the difference-in-differences model in (1.9) by replacing the actual FAS 133 indicator (i.e., 1999–2001) with other period indicators. In the estimation of these tests, I should deal with data limitation since some control variables are not available in the period before 1996.[31] Thus, I perform two different sets of tests: (i) I first consider a short period 1996–1997 and assume that FAS 133 is adopted in 1997, and (ii) I extend the sample period to 1994–1997 and assume that FAS 133 is adopted in 1996. For the data limitation, I consider controls only in the first set of tests.

Table 1.11 reports the results of falsification tests. In all tests, I include

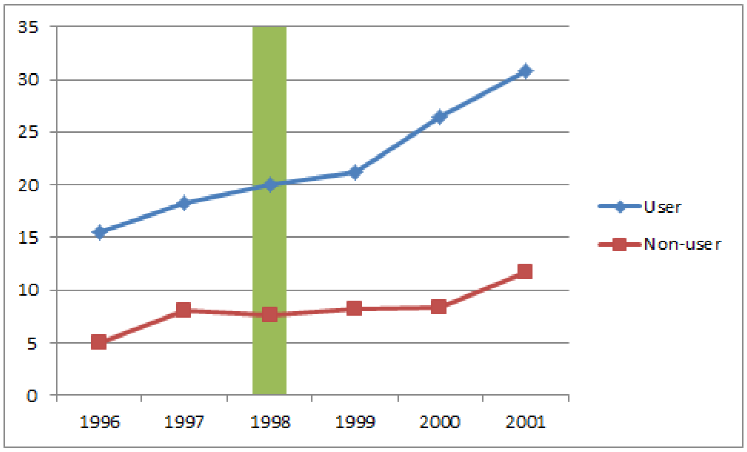
[31] The information on board structure obtained from RiskMetrics is not available before 1996.

firm and industry-year fixed effects. In the tests with a shorter period 1996–1997 (columns 1–4), it is not possible to reject the null hypothesis that *users* and *non-users* have homogeneous change in their CEO compensation structure during this period. This result is robust to the exclusion of controls (columns 1 and 3). In the extended sample period 1994–1997, the falsification tests reject the null hypothesis (columns 5 and 6). As a robustness check, I also conduct the falsification tests for CFO compensation with the extended sample and find that, in contrast to the tests of CEO compensation measures, these tests reject the null hypothesis (columns 7 and 8). Since the falsification tests in the extended period do not include the controls, I compare the estimates with those of the original difference-in-differences models that also control only for firm and industry-year fixed effects. In the original tests with respect to the *Delta* and *Vega* of CEO compensation, the coefficient estimates (t-statistics) are 37.79 (2.07) and 29.70 (2.17), respectively; while the corresponding estimates of falsification tests are merely 20.86 and 18.71. Likewise, the coefficient estimates (t-statistics) of the original tests with respect to the *Delta* and *Vega* of CFO compensation are 8.75 (3.87) and 7.50 (3.62) which are much larger than the corresponding estimates of falsification tests 1.45 and 1.24. Overall, the results show that the CEO compensation structures of *users* and *non-users* exhibit similar trend in 1996–1997 but may have different trends in the extended period 1994–1997. The difference in the trend however grows much larger after FAS 133 is adopted. On the other hand, the CFO compensation structures of *users* and *non-users* show similar trends in 1994–1997. These findings support the validity of estimating the difference-in-differences model.

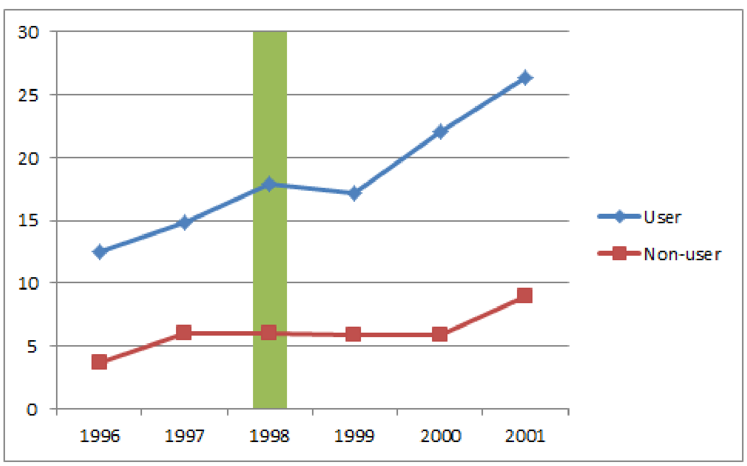
1.6 Concluding remarks

The paper develops a simple model which illustrates that the pay-for-performance sensitivity of the optimal managerial compensation is limited when the manager trades financial assets on behalf of the firm. Consistent with the prediction of the model, the empirical analysis shows that the pay-for-performance sensitivity of managerial compensation contracts is affected by a regulatory change which requires that financial statements disclose comprehensive information about the firm's use of derivative instruments. The paper suggests an important policy implication on derivatives accounting. By disclosing comprehensive information on the financial speculation, the fair value accounting allows for stronger pay-for-performance sensitivity of the managerial compensation and therefore aligns the incentive of the manager more closely with the firm's value. Hence, the evaluation of the accounting standard should not be limited to measuring the changes in firm risks. Rather, more studies should examine whether a regulation enhances the effect of other mechanisms that mitigate agency conflicts.

Figure 1.1: CEO Compensation Structure in 1996–2001



(a) *Delta* in 1996–2001



(b) *Vega* in 1996–2001

This figure plots *Delta* (Panel A) and *Vega* (Panel B) of CEO compensation in 1996–2001. The details about each compensation variable are available in Table 1.1. In each Panel, I separately plot the compensation measures of *users* which traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *non-users*. The sample consists of 2905 firm years of *users* and 1855 firm years of *non-users*. The financial (sic 6000–6999) and utility firms (sic 4900–4999) are excluded from the sample.

Table 1.1: Definition of variables

Variable	Definition
Total$_{i,t}$	Total compensation for the CEO for firm i and year t (tdc1 in Execucomp)
Cash$_{i,t}$	Cash compensation (salary+bonus in Execucomp)
Stock$_{i,t}$	The fair value of restricted stocks granted to the CEO (restrstk in Execucomp)
Option$_{i,t}$	The fair value of stock options granted to the CEO (blk_opt_awards_val in Excucomp)
Delta$_{i,t}$	The increment in the fair value of stocks and options granted to the CEO for a 1% increase in the stock price (following Gormley et al. 2013)
Vega$_{i,t}$	The increment in the fair value of options granted to the CEO for a 1% increase in the stock price volatility (following Gormley et al. 2013)
Ydelta$_{i,t}$	The increment in the fair value of options granted to the CEO for a $1,000 increase in the market value of equity (following Yermack 1995)
ROA$_{i,t}$	Return on Asset reported in Execucomp
Loss$_{i,t}$	Net operating loss dummy (=1 if oibdp$_{i,t}$ <0)
LTD$_{i,t}$	long term debt dummy (=1 if dltt$_{i,t}$ >0)
kz4$_{i,t}$	-1.002*kz_cf$_{i,t}$-39.368*kz_div$_{i,t}$-1.315*kz_c$_{i,t}$+3.139*kz_lev$_{i,t}$
kz_cf$_{i,t}$	(dp$_{i,t}$+ib$_{i,t}$)/at$_{i,t}$
kz_div$_{i,t}$	(dvp$_{i,t}$+dvc$_{i,t}$)/at$_{i,t}$
kz_c$_{i,t}$	che/at$_{i,t}$
kz_lev$_{i,t}$	(dltt$_{i,t}$+dlc$_{i,t}$)/(dltt$_{i,t}$+dlc$_{i,t}$+seq$_{i,t}$)
Return$_{i,t}$	1-year stock return
MB$_{i,t}$	(prcc_f$_{i,t}$*csho$_{i,t}$+at$_{i,t}$-ceq$_{i,t}$-txdb$_{i,t}$)/at$_{i,t}$
R&D$_{i,t}$	3-year moving average of (xrd$_{i,t}$/at$_{i,t}$)
IND$_{i,t}$	Board independence dummy (=1 if the board holds a majority of independent directors)
Ln(tenure)$_{i,t}$	The natural log of the CEO's tenure
NCEO$_{i,t}$	New CEO dummy (=1 for the first year of the CEO)
Dual$_{i,t}$	CEO-Chair dummy (=1 if the CEO is the chairman of the board)

This table presents the definition of compensation variables and control variables. For the fair value of equity grants to managers, I use the corresponding measures provided by Execucomp. For financial and accounting variables, I describe the definition by using the compustat data items. The independent directors are identified by the classification of Riskmetrics database. To identify the CEO/Chair duality, I search the chairperson from Riskmetrics and the CEO from Execucomp. In particualr, the appointment and resignation date of CEOs are provided by Execucomp.

Table 1.2: Intensity in the use of derivatives and industry clusters

Panel A: Derivative holdings

		Intensity			Obs.
		Foreign exchange (FE)	Interest rate (IR)	Total	
User	FE only	0.14	N/A	0.14	155
	IR only	N/A	0.14	0.14	102
	CM only	N/A	N/A	N/A	33
	FE/IR	0.09	0.09	0.18	120
	FE/CM	0.09	N/A	0.09	29
	IR/CM	N/A	0.09	0.09	16
	All	0.06	0.09	0.15	37

Panel B: Industry clusters of *users* and *non-users*

	FF48	Industry	User	Non-user	Ratio	Rank
Top 5	4	Beer & Liquor	4	0	0	1
	27	Precious Metals	6	0	0	2
	2	Food Products	18	3	0.26	3
	24	Aircraft	6	1	0.26	4
	30	Petroleum and Natural Gas	40	9	0.35	5
Bottom 5	26	Defense	2	3	2.36	37
	33	Personal Services	4	6	2.36	38
	7	Entertainment	4	7	2.75	39
	18	Construction	2	6	4.72	40
	43	Restaraunts, Hotels, Motels	4	15	5.90	41
		Total	508	323		

This table presents the summary statistics about holdings of three types of derivatives (foreign exchange, interest rate and commodity derivatives) in 1997 and the relation between derivatives holdings and businesses. The sample consists of 508 *users* which traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and 323 *non-users*. The financial (sic 6000–6999) and utility firms (sic 4900–4999) are excluded from the sample. Panel A presents the intensity in the use of derivatives, which is defined as (fiscal year-end holdings of foreign exchange and interest rate derivatives/book assets) and Panel B reports top-5 and bottom-5 industries in terms of (fraction of *users*/fraction of *non-users*). Industry is classified by Fama-French 48 industry-code. In Panel A, I exclude 16 *users* whose derivative holdings are not available in 10-K filings.

Table 1.3: Summary statistics: Compensation

Panel A: Before FAS 133 (1996–1997)

	Users			Non-users			Diff.	
	mean	sd	median	mean	sd	median	mean	t
Total	4979.86	8314.22	2700.96	2954.03	5190.14	1546.58	2025.83	5.71
Stock	296.12	1177.44	0	242.12	1153.98	0	54	0.85
Option	2483.13	6319.70	749.66	1440.62	4406.82	350	1042.51	3.68
Delta	60.53	149.77	19.47	36.36	137.54	7.81	24.17	3.11
Vega	54.20	136.15	16.26	29.44	108.96	6.07	24.76	3.79
Obs.		929			523			

Panel B: After FAS 133 (1998–2001)

	Users			Non-users			Diff.	
	mean	sd	median	mean	sd	median	mean	t
Total	7210.74	18657.55	3297.85	4408.09	22683.89	1670.69	2802.65	2.40
Stock	462.57	2373.33	0	745.22	18960.75	0	-282.65	-0.34
Option	4530.33	17699.60	1237	2460.55	12109.16	580	2069.78	2.63
Delta	86.62	337.25	25.07	49.23	265.73	10.38	37.39	2.33
Vega	74.89	270.93	21.30	32.87	110.13	7.60	42.02	4.16
Obs.		1976			1332			

This table presents the summary statistics about compensation for CEO and outside directors in the period 1996–2001. The sample consists of 2905 firm years of *users* which traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and 1855 firm years of *non-users*. The financial (sic 6000–6999) and utility firms (sic 4900–4999) are excluded from the sample. Compensation information is obtained from Execucomp database. Panel A (1996–1997) and Panel B (1998–2001) report the compensation structure of *users* and *non-users*. The last two columns in each Panel presents the mean difference between *users* and *non-users* and the unpaired t-statistics (computed for unequal variance and unequal observations) which tests for the null hypothesis that the mean difference is zero. The details about compensation variables are available in Table 1.1.

Table 1.4: Summary statistics: Independent variables

	Users			Non-users			Diff.	
	mean	sd	median	mean	sd	median	mean	t
Ln(asset)	7.64	1.44	7.43	6.31	1.25	6.13	1.33	14.06
Ln(sale)	7.66	1.43	7.53	6.42	1.51	6.44	1.24	11.78
ROA	0.05	0.07	0.05	0.03	0.18	0.06	0.02	1.92
Loss	0.02	0.15	0	0.09	0.29	0	-0.07	-4.09
KZ4	0.20	1.13	0.28	-0.09	1.36	-0.07	0.29	3.19
LTD	0.95	0.22	1	0.82	0.38	1	0.13	5.36
Return	0.17	0.36	0.20	0.15	0.39	0.19	0.02	0.74
MB	1.98	1.15	1.64	2.22	1.44	1.77	-0.24	-2.54
R&D	0.03	0.05	0.01	0.04	0.09	0	-0.01	-1.39
INDBRD	0.72	0.45	1	0.58	0.49	1	0.14	4.19
Ln(tenure)	1.85	0.84	1.95	1.92	0.92	1.95	-0.07	-1.10
NCEO	0.06	0.24	0	0.08	0.28	0	-0.02	-1.32
Dual	0.73	0.44	1	0.64	0.48	1	0.10	2.91
Obs.		508			323			

This table summarizes the firm characteristics of 508 *users* and 323 *non-users* in 1997. I define *users* as the firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997). The financial (sic 6000–6999) and utility firms (sic 4900–4999) are excluded from the sample. I obtain financial and accounting information from Compustat database and board structure from RiskMetrics database. The last two columns in each Panel presents the mean difference between *users* and *non-users* and the unpaired t-statistics (computed for unequal variance and unequal observations) which tests for the null hypothesis that the mean difference is zero. The details about compensation variables are available in Table 1.1.

Table 1.5: The effect of FAS 133 on the structure of CEO compensation: Pay-for-performance sensitivities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
User	30.22***	6.142	-9.446					
	(3.49)	(1.29)	(-0.94)					
FAS133*User	20.50*		24.37*	34.74**	39.88*	37.53*	45.49*	46.97*
	(1.93)		(1.86)	(2.17)	(1.96)	(1.75)	(1.87)	(1.82)
Ln(asset)		41.25***	41.49***		23.03	37.82	22.09	40.78
		(3.97)	(3.92)		(1.35)	(1.53)	(1.15)	(1.39)
Ln(sale)		-7.310	-7.555		38.86**	37.19**	36.73**	35.72**
		(-0.99)	(-1.00)		(2.65)	(2.39)	(2.52)	(2.21)
ROA		-8.131	-8.576		28.87	24.85	30.77	19.39
		(-0.37)	(-0.40)		(0.94)	(0.80)	(1.03)	(0.48)
Loss		-23.94*	-25.04**		-25.03	-20.35	-26.92	-26.50
		(-1.98)	(-2.11)		(-1.14)	(-1.12)	(-0.98)	(-1.32)
KZ4		-3.296	-3.334		-10.95**	-8.023	-5.347	0.721
		(-0.78)	(-0.78)		(-2.22)	(-1.28)	(-0.92)	(0.09)
LTD		19.73	19.67		32.26	57.56	46.45*	65.06
		(0.74)	(0.73)		(1.49)	(1.42)	(1.80)	(1.40)
Return		74.79**	74.99**		77.91**	100.1**	80.84**	106.5**
		(2.21)	(2.21)		(2.54)	(2.29)	(2.37)	(2.16)
MB		25.30***	25.28***		-1.728	-5.381	-6.893	-11.14
		(3.94)	(3.92)		(-0.12)	(-0.29)	(-0.42)	(-0.50)
R&D		171.0*	169.4*		743.3	795.8	724.8	874.2
		(1.90)	(1.90)		(1.64)	(1.25)	(1.67)	(1.24)
INDBRD		-7.693	-7.506		3.617	18.73	7.880	18.73
		(-1.06)	(-1.03)		(0.13)	(0.57)	(0.27)	(0.50)
Ln(tenure)		11.73	11.91		-1.632	0.903	1.139	0.351
		(1.45)	(1.47)		(-0.42)	(0.13)	(0.31)	(0.05)
NCEO		42.01**	42.21**		31.97***		29.78**	
		(2.33)	(2.36)		(3.10)		(2.46)	
Dual		1.104	1.300		2.990	0.998	-1.559	-2.830
		(0.14)	(0.16)		(0.37)	(0.15)	(-0.24)	(-0.36)
Constant	62.14***	-306.4***	-295.8***	39.79***	-467.6**	-586.2**	-450.4**	-609.1*
	(7.74)	(-3.24)	(-3.26)	(6.35)	(-2.58)	(-2.37)	(-2.10)	(-1.99)
Industry FE	Y	Y	Y	N	N	N	N	N
Firm FE	N	N	N	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	N	N
Industry-year FE	N	N	N	N	N	N	Y	Y
N	3878	3878	3878	3878	3878	2868	3878	2868
R-sq	0.034	0.106	0.106	0.005	0.033	0.041	0.065	0.071

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.5: The effect of FAS 133 on the structure of CEO compensation: Pay-for-performance sensitivities

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model. The sample covers the period 1996–1997 (before the issuance of FAS133) and 1999–2001 (after the issuance of FAS 133). After excluding financial (sic 6000–6999) and utility firms (sic 4900–4999), the sample consist of 3878 firm years or 2868 firm years without CEOs appointed during 1997–2001 (columns 6, 8). The dependent variable *Delta* (suggested by Gormley et al. 2013) measures the fair value change of stocks and options granted to the CEO for a 1% increase in the stock price. Independent variables include *Users* which is an indicator of firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *FAS133* which is an indicator of the years in which FAS133 can be adopted (1999–2001). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include industry/year fixed effects in columns 1–4, firm/year fixed effects in 5–6 and firm/industry-year fixed effects in 7–8. The standard errors are robust to industry clusters. For industry fixed effects and industry clusters, I consider the Fama-French 48 industrial classification code. In parentheses, t-statistics are reported.

Table 1.6: The effect of FAS 133 on the structure of CEO compensation: Convexities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
User	29.91***	7.464*	-6.165					
	(3.81)	(1.83)	(-0.82)					
FAS133*User	17.88*		21.31*	27.21**	30.82**	28.57*	34.84*	35.09*
	(1.93)		(1.91)	(2.27)	(2.05)	(1.80)	(1.93)	(1.87)
Ln(asset)		32.00***	32.21***		16.79	29.80	16.23	31.79
		(4.13)	(4.07)		(1.12)	(1.38)	(0.95)	(1.24)
Ln(sale)		-1.230	-1.444		33.97***	31.37***	31.62***	30.34**
		(-0.22)	(-0.25)		(3.08)	(2.71)	(2.83)	(2.53)
ROA		-1.149	-1.539		17.80	15.89	17.77	10.03
		(-0.10)	(-0.14)		(0.84)	(0.67)	(0.81)	(0.32)
Loss		-19.19**	-20.15***		-17.39	-17.99	-18.79	-24.25*
		(-2.64)	(-2.81)		(-1.24)	(-1.38)	(-1.06)	(-1.68)
KZ4		-3.036	-3.069		-9.305**	-6.912	-5.208	-0.414
		(-1.22)	(-1.21)		(-2.34)	(-1.32)	(-1.14)	(-0.06)
LTD		12.90	12.84		25.77	41.66	36.55*	47.34
		(0.65)	(0.64)		(1.57)	(1.36)	(1.80)	(1.35)
Return		59.29**	59.47**		63.71**	79.43**	65.99**	83.81**
		(2.33)	(2.34)		(2.60)	(2.31)	(2.42)	(2.16)
MB		17.50***	17.49***		1.332	-2.388	-2.109	-6.437
		(4.53)	(4.51)		(0.13)	(-0.19)	(-0.19)	(-0.41)
R&D		143.0**	141.6**		525.5	603.9	518.2	658.2
		(2.05)	(2.05)		(1.63)	(1.25)	(1.68)	(1.24)
INDBRD		-3.406	-3.243		6.378	16.17	9.446	15.22
		(-0.58)	(-0.55)		(0.30)	(0.63)	(0.42)	(0.52)
Ln(tenure)		10.17	10.32		-0.838	0.668	1.587	-0.0700
		(1.51)	(1.53)		(-0.25)	(0.11)	(0.49)	(-0.01)
NCEO		32.89**	33.06**		25.69***		24.56**	
		(2.49)	(2.52)		(2.87)		(2.33)	
Dual		-0.649	-0.478		0.852	-0.461	-2.894	-3.658
		(-0.11)	(-0.08)		(0.14)	(-0.08)	(-0.55)	(-0.54)
Constant	44.29***	-272.6***	-263.4***	31.83***	-388.5**	-475.9**	-368.7**	-488.8*
	(6.19)	(-3.82)	(-3.88)	(6.08)	(-2.55)	(-2.32)	(-2.06)	(-1.94)
Industry FE	Y	Y	Y	N	N	N	N	N
Firm FE	N	N	N	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	N	N
Industry-year FE	N	N	N	N	N	N	Y	Y
N	3878	3878	3878	3878	3878	2868	3878	2868
R-sq	0.035	0.112	0.112	0.005	0.034	0.039	0.066	0.070

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.6: The effect of FAS 133 on the structure of CEO compensation: Convexities

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model. The sample covers the period 1996–1997 (before the issuance of FAS133) and 1999–2001 (after the issuance of FAS 133). After excluding financial (sic 6000–6999) and utility firms (sic 4900–4999), the sample consist of 3878 firm years or 2868 firm years without CEOs appointed during 1997–2001 (columns 6, 8). The dependent variable *Vega* (suggested by Gormley et al. 2013) measures the fair value change of options granted to the CEO for a 1% increase in the stock price volatility. Independent variables include *Users* which is an indicator of firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *FAS133* which is an indicator of the years in which FAS133 can be adopted (1999–2001). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include industry/year fixed effects in columns 1–4, firm/year fixed effects in 5–6 and firm/industry-year fixed effects in 7–8. The standard errors are robust to industry clusters. For industry fixed effects and industry clusters, I consider the Fama-French 48 industrial classification code. In parentheses, t-statistics are reported.

Table 1.7: The effect of FAS 133 on the structure of CFO compensation

	(1)	(2)	(3)	(4)	(5)	(6)
	Delta	Delta	Delta	Vega	Vega	Vega
User	-5.030**			-4.272**		
	(-2.10)			(-2.18)		
FAS133*User	6.916***	9.232***	9.305***	6.715***	8.039***	7.880***
	(2.97)	(3.39)	(3.86)	(3.18)	(3.27)	(3.51)
Ln(asset)	10.72***	8.866	8.722	8.602***	6.653	6.363
	(4.13)	(1.52)	(1.64)	(4.65)	(1.45)	(1.56)
Ln(sale)	-1.407	2.935	3.689	-0.241	3.205	3.650*
	(-0.83)	(0.99)	(1.25)	(-0.19)	(1.57)	(1.77)
ROA	-6.988	-2.131	-1.332	-2.804	-1.080	-0.0499
	(-0.83)	(-0.56)	(-0.24)	(-0.71)	(-0.35)	(-0.01)
Loss	0.381	0.929	3.600	-0.337	1.147	3.447
	(0.12)	(0.24)	(0.71)	(-0.14)	(0.41)	(0.95)
KZ4	-0.740	-3.020***	-2.259*	-0.755	-2.507***	-1.821**
	(-0.56)	(-3.42)	(-2.00)	(-1.02)	(-3.06)	(-2.05)
LTD	-0.0839	1.875	2.881	-0.391	1.096	1.521
	(-0.02)	(0.31)	(0.44)	(-0.14)	(0.24)	(0.31)
Return	13.89***	16.72***	17.80***	10.72***	12.87***	13.71***
	(3.73)	(4.56)	(4.22)	(3.96)	(4.55)	(4.28)
MB	5.849***	3.392***	2.571*	3.884***	2.267**	1.688
	(4.47)	(2.76)	(1.85)	(4.63)	(2.33)	(1.49)
R&D	36.23*	122.5**	120.9***	32.50**	104.0**	103.3***
	(1.81)	(2.45)	(2.97)	(2.37)	(2.40)	(2.83)
INDBRD	1.674	4.470*	5.090*	1.895*	4.447**	5.118**
	(1.35)	(1.92)	(1.91)	(1.76)	(2.25)	(2.24)
Ln(tenure)	2.260	4.013**	4.029**	1.892	3.279**	3.240**
	(1.61)	(2.37)	(2.06)	(1.59)	(2.51)	(2.11)
NCEO	4.071	7.391**	6.346**	3.753	7.006***	6.169**
	(1.12)	(2.53)	(2.09)	(1.26)	(2.84)	(2.52)
Dual	-0.660	-0.697	-0.799	-0.648	-0.707	-0.780
	(-0.49)	(-0.32)	(-0.40)	(-0.53)	(-0.39)	(-0.45)
Constant	-82.82***	-97.05***	-100.2***	-71.39***	-80.08***	-80.10***
	(-5.51)	(-3.17)	(-2.99)	(-6.43)	(-2.94)	(-2.86)
Industry FE	Y	N	N	Y	N	N
Firm FE	N	Y	Y	N	Y	Y
Year FE	Y	Y	N	Y	Y	N
Industry-year FE	N	N	Y	N	N	Y
N	2816	2816	2816	2816	2816	2816
R-sq	0.267	0.094	0.165	0.273	0.084	0.163

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.7: The effect of FAS 133 on the structure of CFO compensation

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model. The sample covers the period 1996–1997 (before the issuance of FAS133) and 1999–2001 (after the issuance of FAS 133). After excluding financial (sic 6000–6999) and utility firms (sic 4900–4999), the sample consist of 2816 firm years. As in Gormley et al. (2013), the dependent variables are *Delta* (columns 1–3) which measures the fair value change of stocks and options granted to the CEO for a 1% increase in the stock price and *Vega* (columns 4–6) which measures the fair value change of options granted to the CEO for a 1% increase in the stock price volatility. Independent variables include *Users* which is an indicator of firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *FAS133* which is an indicator of the years in which FAS133 can be adopted (1999–2001). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include industry/year fixed effects in column 1 and 4, firm/year fixed effects in 2 and 5 and firm/industry-year fixed effects in 3 and 6. The standard errors are robust to industry clusters. For industry fixed effects and industry clusters, I consider the Fama-French 48 industrial classification code. In parentheses, *t*-statistics are reported.

Table 1.8: The effect of FAS 133 on the structure of compensation for non-CEO/CFO executives and outside directors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Delta	Delta	Vega	Vega	Delta	Delta	Vega	Vega
FAS133*User	3.078	-0.647	2.402	-0.904	-0.0302	-0.000895	-0.00313	0.0392
	(0.44)	(-0.06)	(0.41)	(-0.10)	(-0.14)	(-0.00)	(-0.02)	(0.19)
Ln(asset)	-10.77	-13.04	-10.33	-11.93	-0.566	-0.583	-0.426	-0.378
	(-0.56)	(-0.63)	(-0.61)	(-0.65)	(-1.41)	(-1.18)	(-1.23)	(-0.94)
Ln(sale)	15.85**	16.70*	14.07**	14.63*	0.846***	0.800**	0.627**	0.571**
	(2.21)	(2.02)	(2.23)	(2.00)	(2.76)	(2.25)	(2.56)	(2.14)
ROA	-8.781	-5.410	-8.413	-5.634	1.740**	1.772**	1.360*	1.336**
	(-1.04)	(-0.68)	(-1.14)	(-0.86)	(2.04)	(2.29)	(2.02)	(2.16)
Loss	1.365	2.127	1.478	2.146	-0.677	-0.424	-0.566	-0.354
	(0.30)	(0.36)	(0.44)	(0.46)	(-1.05)	(-0.66)	(-1.27)	(-0.78)
KZ4	-9.508*	-8.873*	-7.488*	-7.058	-0.249	-0.253	-0.102	-0.106
	(-2.01)	(-1.76)	(-1.85)	(-1.64)	(-0.96)	(-0.93)	(-0.73)	(-0.73)
LTD	11.36	13.28	8.678	10.03	-0.0228	0.169	-0.207	-0.104
	(1.27)	(1.35)	(1.29)	(1.35)	(-0.06)	(0.42)	(-0.74)	(-0.38)
Return	19.06***	19.58***	14.85***	15.27***	2.219***	2.275***	1.564***	1.581***
	(4.54)	(3.77)	(4.57)	(3.74)	(4.37)	(3.92)	(4.61)	(4.06)
MB	5.719**	4.541*	5.188***	4.323***	0.330**	0.280	0.264***	0.236***
	(2.57)	(1.97)	(3.59)	(2.97)	(2.09)	(1.67)	(4.19)	(3.51)
R&D	38.01	42.25	11.84	16.86	13.59	14.17	9.657	10.35
	(0.75)	(0.99)	(0.29)	(0.50)	(1.19)	(1.18)	(1.21)	(1.23)
INDBRD	-2.308	-1.382	-1.988	-1.178	-0.289	-0.266	-0.177	-0.170
	(-0.72)	(-0.45)	(-0.69)	(-0.43)	(-1.34)	(-1.08)	(-1.26)	(-1.07)
Ln(tenure)	5.184	5.541	3.894	4.337	0.0974	0.100	0.109	0.114
	(0.96)	(1.02)	(0.80)	(0.89)	(1.02)	(0.93)	(1.26)	(1.26)
NCEO	8.114	8.852	7.113	8.042	-0.165	-0.192	-0.0985	-0.0943
	(0.87)	(0.86)	(0.86)	(0.89)	(-0.87)	(-0.88)	(-0.67)	(-0.67)
Dual	-5.523*	-5.536*	-4.932*	-5.015*	-0.384*	-0.361*	-0.412**	-0.380*
	(-1.97)	(-1.93)	(-1.99)	(-2.02)	(-1.92)	(-1.77)	(-2.05)	(-1.95)
Constant	-54.88	-37.06	-40.95	-27.04	-1.762	-1.124	-1.148	-1.005
	(-0.69)	(-0.42)	(-0.58)	(-0.35)	(-1.25)	(-0.69)	(-0.87)	(-0.67)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	N	Y	N	Y	N	Y	N
Industry-year FE	N	Y	N	Y	N	Y	N	Y
N	3868	3868	3868	3868	3666	3666	3666	3666
R-sq	0.057	0.129	0.054	0.133	0.127	0.159	0.120	0.153

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.8: The effect of FAS 133 on the structure of compensation for non-CEO/CFO executives and outside directors

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model. The sample covers the period 1996–1997 (before the issuance of FAS133) and 1999–2001 (after the issuance of FAS 133). After excluding financial (sic 6000–6999) and utility firms (sic 4900–4999), the sample consist of 3868 firm years for non-CEO/CFO executives and 3666 firm years for outside directors. As in Gormley et al. (2013), the dependent variables are *Delta* (columns 1–2, 5–6) which measures the fair value change of stocks and options granted to the CEO for a 1% increase in the stock price and *Vega* (columns 3–4, 7–8) which measures the fair value change of options granted to the CEO for a 1% increase in the stock price volatility. Independent variables include *Users* which is an indicator of firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *FAS133* which is an indicator of the years in which FAS133 can be adopted (1999–2001). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include firm fixed effects in all specifications and year fixed effects (in odd columns) or industry-year fixed effects (in even columns). The standard errors are robust to industry clusters. For industry fixed effects and industry clusters, I consider the Fama-French 48 industrial classification code. In parentheses, t-statistics are reported.

Table 1.9: The effect of FAS 133 on the structure of compensation for CEO and CFO: Intensity in the use of derivatives

	(1)	(2)	(3)	(4)
	Delta (CEO)	Vega (CEO)	Delta (CFO)	Vega (CFO)
FAS133*Low	36.59	27.78*	7.325**	5.995**
	(1.62)	(1.69)	(2.35)	(2.24)
FAS133*High	43.79**	34.44**	11.86***	10.85***
	(2.21)	(2.28)	(3.50)	(3.46)
Ln(asset)	23.06	16.81	8.870	6.658
	(1.35)	(1.12)	(1.52)	(1.46)
Ln(sale)	38.93**	34.02***	3.026	3.304
	(2.67)	(3.11)	(1.02)	(1.62)
ROA	28.66	17.60	-2.220	-1.175
	(0.93)	(0.83)	(-0.59)	(-0.39)
Loss	-24.66	-17.05	1.320	1.566
	(-1.14)	(-1.23)	(0.34)	(0.59)
KZ4	-10.90**	-9.257**	-3.021***	-2.507***
	(-2.21)	(-2.32)	(-3.38)	(-3.07)
LTD	32.47	25.96	2.095	1.332
	(1.51)	(1.58)	(0.35)	(0.29)
Return	77.90**	63.70**	16.69***	12.84***
	(2.54)	(2.60)	(4.54)	(4.53)
MB	-1.783	1.281	3.352***	2.223**
	(-0.12)	(0.13)	(2.75)	(2.31)
R&D	741.6	523.9	124.0**	105.6**
	(1.63)	(1.62)	(2.52)	(2.47)
INDBRD	3.608	6.369	4.412*	4.385**
	(0.13)	(0.29)	(1.87)	(2.18)
Ln(tenure)	-1.434	-0.655	4.100**	3.373**
	(-0.36)	(-0.20)	(2.38)	(2.55)
NCEO	32.18***	25.89***	7.461**	7.081***
	(3.14)	(2.89)	(2.53)	(2.85)
Dual	2.962	0.826	-0.719	-0.730
	(0.36)	(0.13)	(-0.33)	(-0.40)
Constant	-468.6**	-389.4**	-97.98***	-81.07***
	(-2.60)	(-2.57)	(-3.24)	(-3.02)
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	3878	3878	2816	2816
R-sq	0.033	0.034	0.095	0.086

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.9: The effect of FAS 133 on the structure of compensation for CEO and CFO: Intensity in the use of derivatives

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model. The sample covers the period 1996–1997 (before the issuance of FAS133) and 1999–2001 (after the issuance of FAS 133). After excluding financial (sic 6000–6999) and utility firms (sic 4900–4999), the sample consist of 3878 firm years for CEO and 2816 firm years for CFO. As in Gormley et al. (2013), the dependent variables are *Delta* (of CEO in column 1 and of CFO in column 3) which measures the fair value change of stocks and options granted to the CEO for a 1% increase in the stock price and *Vega* (of CEO in column 2 and of CFO in 4) which measures the fair value change of options granted to the CEO for a 1% increase in the stock price volatility. Independent variables include *High* (resp. *Low*) which is an indicator of firms whose average holdings of foreign exchange and interest rate derivatives in 1996–97 are more (resp. less) than the median of derivative holdings during the period and *FAS133* which is an indicator of the years in which FAS 133 can be adopted (1999–2001). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include firm fixed effects in all specifications and year fixed effects (in odd columns) or industry-year fixed effects (in even columns). The standard errors are robust to industry clusters. For industry fixed effects and industry clusters, I consider Fama-French 48 industrial classification code. In parentheses, t-statistics are reported.

Table 1.10: Other compensation measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Option/Cash (CEO)	Equity/Cash (CEO)	Option/Cash (CFO)	Equity/Cash (CFO)	Ydelta (CEO)	Ydelta (CFO)	Ydelta (Other)	Ydelta (Board)
FAS133*User	0.176**	0.179**	0.140***	0.127***	0.291	0.152*	0.0966	0.00185
	(2.11)	(2.15)	(3.70)	(3.61)	(0.49)	(2.01)	(0.98)	(0.13)
Ln(asset)	0.322***	0.316***	0.212***	0.192**	-0.544	-0.0590	-0.142	-0.0424***
	(3.76)	(3.54)	(2.88)	(2.60)	(-1.16)	(-0.42)	(-0.83)	(-2.90)
Ln(sale)	-0.142	-0.125	-0.102	-0.0952	-0.661	-0.157	-0.339*	-0.00885
	(-1.35)	(-1.20)	(-1.17)	(-1.16)	(-0.99)	(-0.91)	(-1.93)	(-0.41)
ROA	0.0700	0.0651	0.0198	0.00990	0.781	-0.122	-0.232	0.0785**
	(0.75)	(0.55)	(0.18)	(0.08)	(1.44)	(-0.84)	(-0.69)	(2.37)
Loss	-0.205	-0.185	-0.0608	-0.0462	-1.253	0.0380	0.158	0.000867
	(-1.24)	(-1.11)	(-0.63)	(-0.45)	(-1.26)	(0.19)	(0.72)	(0.01)
KZ4	-0.109***	-0.0940**	-0.0578**	-0.0535**	0.0257	0.0534	0.0499	0.0206***
	(-2.73)	(-2.19)	(-2.47)	(-2.11)	(0.14)	(1.20)	(1.39)	(2.94)
LTD	0.0533	0.0229	-0.0576	-0.0537	0.959	-0.116	0.210	-0.0408
	(0.69)	(0.28)	(-0.86)	(-0.75)	(0.99)	(-0.48)	(0.60)	(-1.39)
Return	-0.00742	-0.00165	0.0612*	0.0821**	0.705***	0.100	0.148**	0.0421*
	(-0.20)	(-0.04)	(1.83)	(2.47)	(2.86)	(1.48)	(2.34)	(1.86)
MB	0.0484	0.0489	0.0709***	0.0755***	0.121	0.0149	0.0596***	0.00322
	(1.40)	(1.44)	(2.89)	(3.07)	(0.83)	(0.43)	(3.30)	(0.61)
R&D	-0.361	-0.174	-0.578	-0.605	6.058	-2.093	2.806	1.335**
	(-0.58)	(-0.33)	(-1.01)	(-1.13)	(1.03)	(-1.06)	(1.40)	(2.54)
INDBRD	-0.0507	-0.0469	0.0320	0.0372	-0.0919	0.165**	-0.0681	-0.0109
	(-0.72)	(-0.69)	(0.95)	(1.03)	(-0.22)	(2.60)	(-1.05)	(-0.53)
Ln(tenure)	-0.0419	-0.0433	0.0562**	0.0661**	-0.451*	0.0250	0.114*	-0.00812
	(-1.44)	(-1.54)	(2.07)	(2.67)	(-1.78)	(0.43)	(1.82)	(-0.69)
Dual	0.340***	0.387***	0.162**	0.175**	1.758***	0.159	0.216**	0.00603
	(4.84)	(5.13)	(2.26)	(2.44)	(3.50)	(1.11)	(2.31)	(0.29)
Constant	0.0677	0.0748	0.0331	0.0347	1.036***	0.0669	0.119*	0.00523
	(1.18)	(1.34)	(0.56)	(0.59)	(2.97)	(0.73)	(1.73)	(0.31)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
N	3861	3861	2819	2819	3876	2815	3866	2995
R-sq	0.065	0.066	0.075	0.077	0.032	0.022	0.028	0.035

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.10: Other compensation measures

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model of which dependent variables are alternative compensation measures: (i) ln(1+option compensaton-to-cash compensation ratio) of CEO in column 1 and of CFO in 3, (ii) ln(1+equity compensaton-to-cash compensation ratio) of CEO in column 2 and of CFO in 4, (iii) the change in the value of option grants (to CEO in column 5, CFO in 6, non-CEO/CEO executives in 7 and outside directors in 8) per $1,000 increase in the market value of equity. The sample covers the period 1996–1997 (before the issuance of FAS133) and 1999–2001 (after the issuance of FAS 133). After excluding financial (sic 6000–6999) and utility firms (sic 4900–4999), the sample consist of 3876 firm years. Independent variables include *Users* which is an indicator of firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *FAS133* which is an indicator of the years in which FAS133 can be adopted (1999–2001). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include firm and year fixed effects. The standard errors are robust to industry clusters. For industry clusters, I consider Fama-French 48 industrial classification code. In parentheses, t-statistics are reported.

Table 1.11: Falsification test: False adoptions in 1996 and 1997

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Delta (CEO)	Delta (CEO)	Vega (CEO)	Vega (CEO)	Delta (CEO)	Vega (CEO)	Delta (CFO)	Vega (CFO)
FAS133*User	19.84	17.55	19.19	17.13	20.86**	18.71***	1.452	1.240
	(1.02)	(1.32)	(1.17)	(1.46)	(2.53)	(2.93)	(0.92)	(0.84)
Ln(asset)		35.00		24.55				
		(0.48)		(0.40)				
Ln(sale)		34.58		22.98				
		(1.20)		(0.85)				
ROA		173.9**		135.6*				
		(2.04)		(1.78)				
Loss		-0.303		-3.283				
		(-0.01)		(-0.17)				
KZ4		20.98		15.23				
		(0.97)		(0.87)				
LTD		172.4		130.7				
		(1.28)		(1.29)				
Return		88.39**		72.69**				
		(2.26)		(2.14)				
MB		16.17		14.79				
		(0.80)		(0.90)				
R&D		1565.1**		1199.0**				
		(2.14)		(2.11)				
INDBRD		4.569		4.840				
		(0.52)		(0.59)				
Ln(tenure)		-9.301		-4.701				
		(-0.80)		(-0.44)				
Dual		12.32		11.20				
		(0.51)		(0.56)				
Constant	41.41***	-722.6	36.09***	-518.6	30.18***	25.07***	8.915***	7.287***
	(5.29)	(-1.20)	(5.43)	(-0.95)	(13.93)	(14.97)	(19.43)	(16.87)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y	Y	Y	Y	Y
N	1287	1287	1287	1287	3327	3327	2313	2313
R-sq	0.058	0.115	0.066	0.111	0.051	0.057	0.080	0.088

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 1.11: Falsification test: False adoptions in 1996 and 1997

(Continued from the previous page)

This table reports the estimates from the difference-in-differences model under the assumption that FAS 133 is adopted in 1996 (columns 1–4) or 1997 (columns 5–8). The sample covers the period 1994–1997 (before the issuance of FAS133). I exclude financial (sic 6000–6999) and utility firms (sic 4900–4999) from the sample. I consider the period 1996–1997 in columns 1–4 and the period 1994–1997 in 5–8. As in Gormley et al. (2013), the dependent variables are *Delta* (of CEO in columns 1,2,5 and of CFO in 7) which measures the fair value change of stocks and options granted to the CEO for a 1% increase in the stock price and *Vega* (of CEO in columns 3,4,6 and of CFO in 8) which measures the fair value change of options granted to the CEO for a 1% increase in the stock price volatility. Independent variables include *Users* which is an indicator of firms having traded derivatives before the issuance of FAS 133 (i.e., 1996–1997) and *FAS133* which is an indicator of the false years in which FAS133 is adopted (i.e., 1997 in columns 1–4 and 1996–1997 in columns 5–8). Other control variables are available in Table 1.1. Independent variables, except for *INDBRD* and *NCEO*, are lagged by one year. I include firm fixed effects in all specifications and year fixed effects (in odd columns) or industry-year fixed effects (in even columns). The standard errors are robust to industry clusters. For industry-year fixed effects and industry clusters, I consider the Fama-French 48 industrial classification code. In parentheses, t-statistics are reported.

Chapter 2

CEO Compensation, Board Compensation, and Managerial Risk-Seeking Activities

2.1 Introduction

Since Jensen and Meckling (1976) financial economists have focused on agency conflicts between the shareholders and the manager of the corporation and have analyzed a number of mechanisms that shareholders can employ to mitigate these conflicts. Among these mechanisms, managerial compensation and board monitoring have been considered essential to reducing these conflicts. Specifically, the standard view in the literature is that the misalignment of incentives between managers and shareholders can be reduced by either adequately designing managerial compensation or alternatively by delegating managerial monitoring to the board of directors.[1]

While the literature has extensively analyzed the effectiveness of these two alternate mechanisms in isolation, this paper departs from the literature by considering the two mechanisms jointly, and in particular, by incorporating two key features of the relationships between shareholders, boards and managers. First, I consider a setting in which shareholders delegate to the board

[1] See Frydman and Jenter (2010) and Adams et al. (2010) for surveys of recent research on managerial compensation and board of directors, respectively.

the tasks of managerial monitoring and the design of managerial compensation.[2] Second, I model the board's agency problems in performing these tasks and solve for the board compensation that maximizes shareholder value.[3] By considering a setting in which managerial and board incentives are endogenously determined, I can investigate a number of empirical issues related to board and managerial compensation.

In practice, board compensation has recently exhibited wide variation in its structure across firms. For instance, in 2006 Coca-Cola Co. abandoned the use of non-contingent compensation for outside directors and instead started awarding them performance-based compensation related to earnings-per-share growth. In the same year, IBM moved in the opposite direction by abandoning option grants to outside directors and reinstating a non-contingent annual compensation of $200,000. These contrasting decisions suggest that a trade-off exists in the use of pay-for-performance board compensation. In this analysis, I examine this trade-off by considering how a board compensation structure influences the board's functions within the corporation which, as established by the literature (e.g., Adams et al. 2010), are associated with the monitoring of managerial activities and the design of managerial pay among their other duties.

[2]The importance of the board in monitoring the manager and in setting the managerial pay is well described in the US Senate report *The role of the board of director in Enron's collapse* which finds that the board of Enron failed to ensure the disclosure of off-the-book liabilities and approved high-risk accounting and excessive compensation for executives.

[3]Bebchuk and Fried (2004) highlights the practical importance of board agency conflicts, particularly, in the design of managerial compensation.

Intuitively, the main trade-off in the structure of board compensation is that while high pay-for-performance compensation provides the board with incentives to properly design managerial compensation, it also diminishes the board's incentives to monitor and report unproductive managerial risk-shifting activities. As I show, these competing incentives related to the board's two monitoring functions suggest that the cross-sectional variations in managerial and board pay-for-performance compensation are not mutually independent of one another and that further insight can be gained by analyzing them in tandem.

To formally analyze the double incentive provision problem for managers and boards, I consider a firm that operates a project whose quality is private information to the manager in charge and whose success depends on a specific set of managerial actions. These managerial actions fall into two categories: (i) costly managerial actions (e.g., operational choices that require managerial effort) which enhance the firm's value without affecting the risk of its cash-flows and (ii) costless managerial risk-seeking activities (e.g., financial speculation or over-investment in risky activities) which increase the risk of the firm's cash flows without affecting the firm value.

I model the board as a single agent who can acquire information about the project's quality at some cost, and can also observe managerial risk-seeking activities. Since optimal managerial actions depend on the project's quality, it may appear optimal to delegate to the board the authorities to monitor the manager and to fine tune managerial compensation. This conclusion, however, is not necessarily correct since shareholders, who do not observe the board's information, can only rely on the design of board compensation to influence the board's behavior. As it turns out, depending on parameters related to the nature of the managerial and board agency problems, several optimal governance arrangements are possible. In some of these governance arrangements, shareholders rely on more intense board monitoring and managerial compensation is delegated to the board. In other arrangements shareholders choose less reliance on board monitoring. Each of these arrangements corresponds with an optimal compensation structure for the board and the manager. Therefore, the model analysis gives rise to a number of empirical predictions which link the joint compensation structure to the parameters that characterize the nature of managerial and board agency problems.

First, my analysis proposes a test that considers how the combined use of pay-for-performance for boards and managers is affected by the managerial ability to engage in risk-seeking activities. Specifically, in the absence of agency conflicts regarding risk-seeking activities, the optimal compensation structure exhibits a high pay-for-performance sensitivity in both managerial and board compensation. This result aligns with the intuition that high pay-for-performance board compensation provides the board with incentives to fine-tune the design of managerial compensation by monitoring the project's quality. However, when the manager can easily engage in risk-seeking activities, awarding high pay-for-performance compensation to both managers and boards can produce undesirable effects since such a compensation structure would prompt the manager to engage in risk-seeking activities while simultaneously reducing the board's incentive to disclose the manager's engagement in risk-seeking activities to shareholders. To test this prediction, I examine whether firms reduce the combined use of high pay-for-performance compensation to both managers and boards as the managerial ability to engage in risk-seeking activities increases.

Second, this model proposes that the size of the board's monitoring costs is a key determinant of the optimal joint compensation structure. Specifically, when monitoring costs are low, boards do not require high pay-for-performance compensation to tailor managerial compensation by acquiring information about the project's quality. Thus, as board monitoring costs decrease, shareholders will use reduced pay-for-performance board compensation while inducing the board to grant high pay-for-performance to the manager.

Finally, the model analysis also suggests that when a firm's project exhibits a large variability in quality, it becomes likely that low pay-for-performance board compensation is optimal. Intuitively, even with low pay-for-performance compensation, boards find it costly to design managerial compensation without acquiring information about the project's quality (i.e., to award low pay-for-performance compensation to the manager in charge of a high-quality project or vice versa). Therefore, in these conditions the optimal compensation structure simultaneously grants low pay-for-performance compensation to boards and high pay-for-performance to managers.

To test the empirical predictions provided by the model analysis, I analyze S&P 1500 companies in the years 1996–2005 and use R&D firms and banks as proxies for high managerial risk-shifting ability, outside directors' ownership as a proxy for board monitoring costs and business complexity measures (i.e., firm size and the number of business segments) as proxies for the project's variability in their quality. To empirically measure the combined use of pay-for-performance compensation for managers and boards, I consider information on option grants. Specifically, I classify the sample firm years into four groups, namely, (high-high, high-low, low-high, low-low), which correspond to the magnitudes of manager-board pay-for-performance sensitivities. Then, I estimate the effect of the determinants on the joint compensation structure using the multinomial logit regressions.

The main empirical findings are as follows. First, after controlling for common determinants (e.g., Yermack 1995), I find that when the manager has opportunities to substantially shift the firm's risks, the combined compensation structure exhibits high pay-for-performance for managers and low pay-for-performance for boards. Relative to other firms, R&D firms show around 6% higher odds of awarding options only to managers. Second, firms in which non-officer blockholders sit on the board are also more likely to award high pay-for-performance compensation to managers and low pay-for-performance compensation to boards. Specifically, the presence of blockholders on the board leads to 5% higher likelihood of awarding stock options to managers alone. Finally, I also find that business complexity is positively related to the simultaneous award of high managerial and low board pay-for-performance but it is negatively related to awarding high pay-for-performance to both simultaneously. With all other factors being equal, an additional business segment is associated with a 2% increase in the likelihood of awarding option plans only to the manager.

This study is related to several branches of the corporate governance literature. First, my model contributes to the theoretical literature on corporate governance that considers the interaction between managerial pay and boards. Previous studies have shown that managerial pay is affected by the degree of influence that a manager has on the board (i.e., the board structure) and they have considered the optimal board structure when managerial pay is endogenous.[4] As shown above, by incorporating board agency conflicts and the board's role in the design of managerial pay into the analysis, my study generates a number of cross-sectional implications between firm characteristics and the joint nature of managerial and board compensation.

In addition, my empirical findings offer new evidence on the determinants of board compensation.[5] Previous empirical studies have found a substantial variation in board incentives and have reported a number of determinants of board incentive compensation. For instance, Yermack (2004) shows that, on average, board compensation exhibits a considerable pay-for-performance sensitivity while Ryan and Wiggins (2004) finds that board com-

[4]See, e.g., Almazan and Suarez (2003) and Kumar and Sivaramakrishnan (2008).

[5]See e.g., Ryan and Wiggins (2004), Yermack (2004), Fich and Shivdasani (2005), Adams and Ferreira (2008), and Kumar and Sivaramakrishnan (2008) among others.

pensation is related to the firm's internal governance. In this study I propose and test for other important determinants of board compensation and their relationship to managerial pay.

Finally this paper also contributes to the literature on managerial compensation and in particular re-examines how the convexity of managerial compensation affects managerial risk-taking behavior.[6] While agency theory tends to predict that convex managerial compensation leads to risk-seeking corporate policies, the previous empirical studies have led to inconclusive results. My analysis provides a possible explanation for these inconclusive results. Specifically, while highly convex managerial compensation may certainly induce managers to engage in risk-seeking activities, these activities only occur when the board also receives a convex compensation structure and allows these activities to materialize. Thus, my analysis suggests that empirical studies should include measures of board compensation convexity when testing the effects of managerial compensation on risk-seeking corporate behavior.

The paper is organized as follows. Section 2 describes the model. Sections 3 and 4 solve the model. Section 5 discusses the results of the model analysis and develops empirical predictions which I take to data in the second part of this paper. Section 6 describes the data. Section 7 presents the empirical results. Finally, section 8 discusses concluding remarks.

[6]See, e.g., Coles et al. (2006), Chava and Purnanandam (2010), and Hayes et al. (2012) for the papers that have empirically investigated how managerial compensation affects risk-taking managerial behavior.

2.2 The model

I consider an all-equity firm that operates in a risk-neutral economy where the market rate of return is normalized to zero. The firm is run by a manager who has no wealth, is protected by limited liability and has a zero reservation utility. There is also a board of directors (the board, hereafter) that can monitor the manager and to whom the design of managerial compensation is delegated. To focus the analysis exclusively on the board's incentives and compensation, I model it as a risk-neutral single agent, protected by limited liability and with zero wealth and zero reservation utility.[7]

In line with previous literature (e.g., Faure-Grimaud et al. 2003), I consider a firm organized as a two tier hierarchy: in the first tier (i.e., the *shareholder-board tier*) shareholders communicate and contract with the board and in the second tier (i.e., the *board-manager tier*), the board subsequently communicates and contracts with the manager.[8] In this setting I solve for the optimal contracting choices made by the shareholders and the board and then consider the implications that emanate from them.

[7]This modelling choice abstracts from issues related to board composition. See Adams et al. (2010) for a recent literature review on board composition.

[8]Faure-Grimaud et al. (2003) also examines a two-tier hierarchy with decentralized contracting structure in which the principal contracts exclusively with an intermediary who is delegated the authority to contract with the agent.

2.2.1 Firm project and managerial actions

The firm's assets consist of a project that yields a random terminal cash flow $\tilde{r} = \{r^d, r^m, r^u\}$, where $r^m = \frac{r^u + r^d}{2}$ and $0 < r^d < r^u$ and whose probability distribution is affected by (i) a project's productivity type $\theta \in \{\theta_l, \theta_h\}$, where $0 < \theta_l < \theta_h < \frac{1}{3}$ and $prob(\theta = \theta_h) = p$, and (ii) two managerial actions e and Δ described below.

Specifically, the project's cash-flow distribution is as follows:

$$\tilde{r} = \begin{cases} r^u & \text{with prob. } \frac{1}{3} + \theta e + \Delta \\ r^m & \text{with prob. } \frac{1}{3} - 2\Delta \\ r^d & \text{with prob. } \frac{1}{3} - \theta e + \Delta, \end{cases} . \tag{2.1}$$

I refer to $e \in [0, 1]$ as "managerial effort" which is privately *costly* to the manager

$$c(e) = \frac{1}{2}\gamma_m e^2. \tag{2.2}$$

As shown in (2.1), relative to $e = 0$ which is the minimum effort choice, $e > 0$ increases the likelihood of r^u at the expense of r^d and thus increases the firm's expected cash-flow by $\theta(r^u - r^d)e$. Furthermore, I refer to $\Delta \in \{\Delta_0, \Delta_s\}$ (where $0 = \Delta_0 < \Delta_s < \frac{1}{6}$) as the managerial "risk choice" which is *costless* to the manager. Relative to Δ_0, the risk choice Δ_s is a mean-preserving spread which increases the likelihood of extreme cash flows r^u and r^d at the expense of the moderate cash flow r^m.[9]

[9] The possibility of costless risk-management choices allows me to consider a particularly relevant case namely the case in which a manager can make financial transactions on behalf of their firms. Net of transaction costs, financial transactions are ex-ante zero NPV transactions that affect cash-flow risk without altering the its value. In this sense, this analysis can be interpreted as an analysis of the provision of managerial and board incentives when a manager can engage in financial speculation.

2.2.2 Managerial private information and board monitoring

The manager has private information about the project's type θ and takes hidden actions e and Δ. I assume that shareholders cannot observe any of the managerial information, but the board can monitor and obtain information about the project's type and the managerial actions. In particular, in this setting the board monitoring technologies with respect to θ, e and Δ differ in their required monitoring costs (which reflects the level of difficulty that the board encounters in monitoring each type of information) and in the feasibility of producing hard evidence about the acquired information (which reflects the possibility to translate each type of information into a verifiable report).

Relative to the board monitoring costs, I assume that the board cannot observe e at any cost (i.e., the board cannot measure the managerial effort choice) but it can privately observe the project's type θ by incurring a private cost γ_b and also privately observe the manager's choice of Δ at no cost. The assumption of the board's ability to observe managerial risk choices is consistent with regulations such as the Sarbanes-Oxley Act which authorize the board to review the firm's risk-management strategy and to discuss it with management.[10]

With regard to the production of hard evidence, I assume that the board produces none when monitoring θ and that, by contrast, produces some

[10] Géczy et al. (2007) finds that management regularly reports to the board about the firm's (speculative) derivative transactions.

publicly observable hard evidence after monitoring the risk choice Δ. This distinction is consistent with the insight that information about project quality is likely to be soft and thus unverifiable by third parties, while managerial risk choices have a quantitative dimension that can be communicated to third parties in the form of verifiable reports (e.g., financial statements).[11]

Technically, I assume that θ can only be reported via board announcements $\hat{\theta}_b$ to the shareholders while after observing $\Delta = \{\Delta_0, \Delta_s\}$ the board produces verifiable hard evidence $\hat{\Delta} = \{\hat{\Delta}_0, \hat{\Delta}_s\}$ which is however subject to the following agency conflict. When the manager chooses Δ_s, the board may report otherwise (i.e., the board can either report $\hat{\Delta}_0$ or $\hat{\Delta}_s$) but when the manager chooses Δ_0, the board truthfully reports it (i.e., the board can only report $\hat{\Delta}_0$). In other words, $\hat{\Delta}_s$ is always truthful evidence of the manager's choice of Δ_s while $\hat{\Delta}_0$ does not necessarily reveal the managerial choice of Δ_0.[12]

For the future reference I refer to $(\hat{\Delta}^z, \hat{\theta}^z) \in \{\Delta_0, \Delta_s\} \times \{\bar{\theta}, \theta_l, \theta_h\}$ as the board's information status relative to Δ and θ where Δ_j $(j = 0, s)$ corresponds to the case in which the board observes the manager's risk choice and θ_i $(i = l, h)$ to the case in which the board monitors and observes the project's

[11]For instance, in the financial statements each of derivative transactions is explicitly classified into either hedging or speculative investments.

[12]Since Δ_s corresponds to the case in which the manager takes an action that will be detrimental to shareholder value, the board's inability to forge the evidence $\hat{\Delta}_s$ allows me to rule out the impractical case in which boards incriminate managers by producing a false evidence of managerial misbehavior. This modelling choice is typically considered in the delegation literature (e.g., Tirole 1986) to capture agency conflicts in the production of information supervisors.

type θ_i and $\bar{\theta}$ to the case in which the board does not monitor θ.

In summary, as is common in the delegation literature (e.g., Tirole 1986) I analyze a nested informational structure in which the manager's information set is a finer partition of the board's information set which in turn is a finer partition of the information set of shareholders. In the *shareholder-board tier*, shareholders do not observe either the board's information $(\hat{\theta}^z, \hat{\Delta}^z)$ or whether the board forges the evidence $\hat{\Delta}$ and in the *board-manager tier*, the board can monitor to learn θ and Δ (but not e) while the manager observes $(\hat{\theta}^z, \hat{\Delta}^z)$ i.e., the board's information status.[13]

2.2.3 Collusion, communication and contracts

The analysis solves for the design of the optimal managerial and board compensation in a sequential contracting framework. As discussed below, the analysis takes into account the aspect that communication is limited to parties within tiers and thus that some contracts are unfeasible due to limited communication. Within this setting, I consider the design of the optimal board compensation by shareholders within the *shareholder-board tier*, and, then, the subsequent design of optimal managerial compensation by the board within the *board-manager tier*.

An important element of the analysis is the possibility that the manager and the board can collude to obtain additional rents at the expense of the

[13]Strictly speaking, not all information structure is nested in this analysis since, as shown below, the manager does not observe the board's messages sent to shareholders.

shareholders. As in Tirole (1986) collusion is modelled by assuming that the board can pre-commit to produce a certain report about the managerial choice of Δ_s before the manager actually chooses Δ.[14] Formally, I denote the board's commitment as $\phi \in \{t, f\}$, where $\phi = t$ corresponds to truthfully reporting $\hat{\Delta}_s$ and $\phi = f$ to falsely reporting $\hat{\Delta}_0$.[15] I assume that shareholders do not observe ϕ which, as shown below, implies that the possibility of board-manager collusion crucially affects the design of the compensation contracts.

In this setting feasible contracts are limited by the availability of information and by inability to communicate with parties in different tiers. Specifically, feasible contracts can be written on: (i) the hard information produced by the board's report $\hat{\Delta}$ and (ii) the messages sent by the manager (to the board) and by the board (to the shareholders) relative to the soft private information that they may have. In particular, the manager sends to the board a message $\hat{\theta}_m \in \{\theta_l^m, \theta_h^m\}$ relative to θ while the board sends a message to shareholders $\mu_b = (\hat{\theta}_b, \hat{\theta}_b^m)$, where $\hat{\theta}_b \in \{\theta_l^b, \theta_h^b, \bar{\theta}^b\}$ corresponds to the message about its information $\hat{\theta}^z$ and $\hat{\theta}_b^m \in \{\hat{\theta}_l^b, \hat{\theta}_h^b\}$ to the message about the manager's message $\hat{\theta}_m$.[16] In line with the delegation literature, I assume that these mes-

[14]This resembles the framework in Tirole (1986) in which a supervisor and an agent can collude at the expense of the principal. As in that framework I assume that this commitment is self-enforceable, i.e, that can be implemented without the assistance of a third-party enforcing it.

[15]The board reporting action after managers choose $\Delta = \Delta_0$ is by assumption $\hat{\Delta}_0$, i.e., the board cannot forge the report when the manager chooses Δ_0.

[16]By the "generalized revelation principle" (Myerson 1982), the restrictions of the manager and board message spaces are without loss of generality. The board also observes the manager's choice of Δ and therefore can communicate about it with shareholders. As it turns out, considering the board's message about Δ does not affect the results since the

sages are observed by the two parties within each tier but cannot be observed by the party outside a tier.[17] In other words, shareholders and the manager who are not in direct communication with each other do not observe $\hat{\theta}_m$ and $(\hat{\theta}_b, \hat{\theta}_b^m)$, respectively.

Formally, feasible contractual arrangements in each tier are as follow.[18] First, within the *board-manager tier* the board commits to $\phi(\hat{\theta}_m)$ and offers a managerial compensation contract $w_m(\hat{\theta}_m, \hat{\Delta}, \tilde{r})$ which, for convenience, can be rewritten as:

$$w_m(\hat{\theta}_m, \hat{\Delta}, \tilde{r}) = \Big(u_m(\hat{\theta}_m, \hat{\Delta}), m_m(v), d_m(\hat{\theta}_m, \hat{\Delta})\Big), \tag{2.3}$$

where $k_m(.)$ $(k = u, m, d)$ corresponds to the managerial pay for the realized cash flow r^k.

Second, within the *shareholder-board tier* shareholders design the board compensation contract with limited information about the managerial compensation contract offered by the board. In particular I assume that while the board offers a menu of contracts to the manager, shareholders can observe only the specific part of the menu chosen by the manager and cannot observe other elements in the menu offered to the manager. This assumption, which

managerial compensation which induces the manager's choice of Δ cannot be written upon the board's message to shareholders.

[17] Other studies in the delegation literature (e.g., Baliga and Sjöström 1998 and Faure-Grimaud et al. 2003) also consider a setting in which parties can write contracts contingent on messages sent to each other within a tier but not on messages sent by parties in other tiers.

[18] To facilitate the presentation I describe these arrangements in the reverse order of their actual contracting sequence.

is consistent with the premise that a party has limited information about contracts made outside its own tier, allows the model to capture in a simple way the trade-off that shareholders face when they delegate managerial compensation to the board.[19] While by delegating the task to a better informed party (i.e., the board) shareholders can use the board's information in the design of managerial compensation, they cannot take full advantage of the board's information since they have only limited access to relevant aspects about the pay-setting process.

Formally, within the *shareholders-board tier* shareholders design the board pay w_b as a function of observables $(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta}, \tilde{r}, \sigma_m)$, where σ_m corresponds to the part of the menu of managerial compensation observed by shareholders, namely, the managerial choice within the menu of contracts. In particular, when the board offers the manager $[w_m(\hat{\theta}_m, \hat{\Delta}, \tilde{r}), \phi(\hat{\theta}_m)]$ and the manager subsequently chooses $(\hat{\theta}_m^*, \Delta^*) \in (\{\theta_l^m, \theta_h^m\}, \{\Delta_0, \Delta_s\})$, shareholders observe

$$\sigma_m = w_m(\hat{\theta}_m^*, \hat{\Delta}^*, \tilde{r}) = (u_m(\hat{\theta}_m^*, \hat{\Delta}^*), m_m(\hat{\theta}_m^*, \hat{\Delta}^*), d_m(\hat{\theta}_m^*, \hat{\Delta}^*)),$$

where $\hat{\Delta}^* \in \{\hat{\Delta}_0, \hat{\Delta}_s\}$ is the board's report $\hat{\Delta}$ that corresponds to $\phi(\hat{\theta}_m^*)$ and Δ^*. Analogously to (2.3), w_b can be written as:

$$w_b(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta}, \tilde{r}, \sigma_m) = \{u_b(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta}, \sigma_m), m_b(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta}, \sigma_m), d_b(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta}, \sigma_m)\}, \tag{2.4}$$

[19]This is also in line with the observation made in Bebchuk and Fried (2004) who document a number of examples in which boards resort to hard-to-observe (i.e., "camouflage") compensation for managers.

where $k_b(.)$ $(k = u, m, d)$ corresponds to the board pay for the realized cash flow r^k. To alleviate the notation, in what follows I will refer to the menus of contracts $w_m(\hat{\theta}_m, \hat{\Delta}, \tilde{r})$ and $w_b(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta}, \tilde{r}, \sigma_m)$ as w_m and w_b when no confusion arises.

2.2.4 Sequence of events

The sequence of events unfolds as follows. At $t = 0$, shareholders offer w_b to the board. At $t = 1$, the board monitors θ, offers the compensation contract w_m and commits to report ϕ. At $t = 2$, the manager chooses e and Δ and sends a message $\hat{\theta}_m$ to the board. At $t = 3$, the board reports $(\hat{\theta}_b, \hat{\theta}_b^m, \hat{\Delta})$ to the shareholders who, in turn, observe σ_m. At $t = 4$, the firm's cash flows are realized and contracts are enforced.

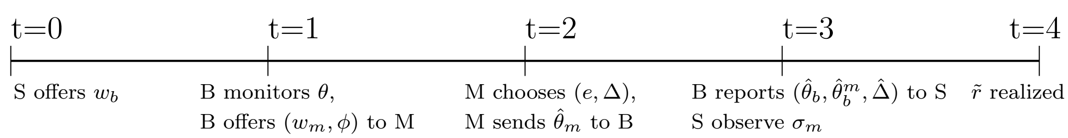


Figure 1. Sequence of events

The analysis of the model can be simplified by solving for the optimal compensation and actions in two mutually exclusive cases that differ on whether or not the board monitors and acquires information on θ. Specifically, in the *uninformed board case*, the board designs managerial compensation without monitoring θ while in the *informed board case*, the board optimally chooses to monitor θ before designing the managerial compensation.[20] While most of the interesting comparative statics arises in the analysis of the informed board case, the analysis of the uninformed board case provides a natural benchmark. Thus, in Section 2.3 I first solve for the optimal compensation and actions when the board is uninformed and compare them with the informed board case analyzed in Section 2.4.

Solving the model requires to obtain the managerial and board compensation and to characterize the associated managerial and board choices induced by the compensation contracts. Technically, the model features a sequence of three optimization problems in which: (i) shareholders solve for the optimal board compensation w_b^* to affect the board's incentives to design managerial compensation and to monitor θ and Δ; (ii) the board, in turn, solves for the optimal managerial compensation w_m^* and disclosure commitment ϕ^* taking into account how they affect the managerial choices of $(\hat{\theta}_m, e, \Delta)$; and (iii) the manager chooses $(\hat{\theta}_m^*, e^*, \Delta^*)$ that maximizes his expected utility.

2.3 Model analysis (I): Uninformed board

The *uninformed board case* corresponds to the case in which shareholders set board compensation w_b^U to induce the board to choose (w_m^U, ϕ^U) without learning θ. Formally, solving this model requires to consider a sequence of two mechanism design problems, one in each organizational tier.

[20]This is without loss of generality. Considering the possibility of a mixed monitoring strategy in which the board incurs γ_b with probability $q \in (0, 1)$ does not change the results.

In the *board-manager tier*, the board chooses (w_m^U, ϕ^U) to provide incentives to the manager who is privately informed about θ and will take two hidden actions (e, Δ). In the *shareholders-board tier*, shareholders design w_b^U for the board who can observe the managerial choice of Δ and communicates with the manager to receive information about θ. In what follows, I denote the sequence of optimal mechanisms chosen by shareholders and the board as $M^{U*} = \{w_b^{U*}, (w_m^{U*}, \phi^{U*})\}$.

By virtue of the generalized revelation principle (Myerson 1982), M^{U*} belongs to the set of truth-telling mechanisms in which: (i) in the *board-manager tier* the manager sends a message to the board $\hat{\theta}_m \in \{\theta_l^m, \theta_h^m\}$ which truthfully reveals θ and (ii) in the *shareholders-board tier* the board sends a message to shareholders $\hat{\theta}_b^m \in \{\hat{\theta}_l^b, \hat{\theta}_h^b\}$ which truthfully reveals the manager's message $\hat{\theta}_m$.[21] Thus, the shareholders' problem can formally stated as follows:

[21]Without loss of generality I omit the board's message about its information status relative to the monitoring decision (i.e., $\hat{\theta}^z = \bar{\theta}$) since shareholders can infer that the board optimally remains uninformed about θ.

$$\max_{w_b} \ pV_s\left(w_b \mid \hat{\theta}^b_h\right) + (1-p)V_s\left(w_b \mid \hat{\theta}^b_l\right) \tag{2.5}$$

subject to

$$(\hat{\theta}^{h^*}_b, \hat{\theta}^{l^*}_b, w^*_m, \phi^*) = \underset{\hat{\theta}^h_b, \hat{\theta}^l_b, w_m, \phi}{\operatorname{argmax}}\, pV_b\left(\hat{\theta}^h_b, w_m, \phi \mid \theta^m_h, w_b\right) + (1-p)V_b\left(\hat{\theta}^l_b, w_m, \phi \mid \theta^m_l, w_b\right) \tag{2.5.1}$$

subject to

$$(\hat{\theta}^i_m, e^i, \Delta^i) = \underset{\hat{\theta}_m, e, \Delta}{\operatorname{argmax}} V_m(\hat{\theta}_m, e, \Delta \mid \theta_i, w_m, \phi) \text{ for } i = h, l \tag{2.5.1.a}$$

$$\hat{\theta}^i_m = \theta^m_i \text{ for } i = h, l \tag{2.5.1.b}$$

$$u_m(\hat{\theta}_m, \hat{\Delta}) \geq m_m(\hat{\theta}_m, \hat{\Delta}) \geq d_m(\hat{\theta}_m, \hat{\Delta}) \geq 0, \tag{2.5.1.c}$$

$$\hat{\theta}^{i^*}_b = \hat{\theta}^b_i \text{ for } i = h, l \tag{2.5.2}$$

$$u_b(\hat{\theta}^m_b, \hat{\Delta}, \sigma_m) \geq m_b(\hat{\theta}^m_b, \hat{\Delta}, \sigma_m) \geq d_b(\hat{\theta}^m_b, \hat{\Delta}, \sigma_m) \geq 0 \tag{2.5.3}$$

where, for $i = h, l$,

$$\begin{aligned} V_m\left(\hat{\theta}_m, e, \Delta \mid \theta_i, w_m, \phi\right) &= \left(\frac{1}{3} + \theta_i e + \Delta\right) u_m(\hat{\theta}_m, \hat{\Delta}) + \left(\frac{1}{3} - 2\Delta\right) m_m(\hat{\theta}_m, \hat{\Delta}) \\ &\quad + \left(\frac{1}{3} - \theta_i e + \Delta\right) d_m(\hat{\theta}_m, \hat{\Delta}) - \frac{\gamma_m e^2}{2}, \end{aligned} \tag{2.6}$$

for $\hat{\Delta} = \begin{cases} \hat{\Delta}_s & \text{if } \Delta = \Delta_s \text{ and } \phi(\theta^m_i) = t \\ \hat{\Delta}_0 & \text{otherwise,} \end{cases}$

$$\begin{aligned} &V_b\left(\hat{\theta}^i_b, w_m, \phi \mid \theta^m_i, w_b\right) \\ &\quad = \left(\frac{1}{3} + \theta_i e^i + \Delta^i\right) u_b\left(\hat{\theta}^i_b, \hat{\Delta}, \sigma_m\right) + \left(\frac{1}{3} - 2\Delta^i\right) m_b\left(\hat{\theta}^i_b, \hat{\Delta}, \sigma_m\right) \\ &\quad\quad + \left(\frac{1}{3} - \theta_i e^i + \Delta^i\right) d_b\left(\hat{\theta}^i_b, \hat{\Delta}, \sigma_m\right) \end{aligned} \tag{2.7}$$

and

$$
\begin{aligned}
&V_s\left(w_b \mid \hat{\theta}_i^b\right) \\
&\quad = \left(\frac{1}{3} + \theta_i e^i + \Delta^i\right)\left[r^u - u_b\left(\hat{\theta}_i^b, \hat{\Delta}, \sigma_m\right) - u_m(\theta_i^m, \hat{\Delta})\right] \\
&\quad\quad + \left(\frac{1}{3} - 2\Delta^i\right)\left[r^m - m_b\left(\hat{\theta}_i^b, \hat{\Delta}, \sigma_m\right) - m_m(\theta_i^m, \hat{\Delta})\right] \\
&\quad\quad + \left(\frac{1}{3} - \theta_i e^i + \Delta^i\right)\left[r^d - d_b\left(\hat{\theta}_i^b, \hat{\Delta}, \sigma_m\right) - d_m(\theta_i^m, \hat{\Delta})\right].
\end{aligned} \tag{2.8}
$$

for $\sigma_m = w_m(\theta_i^m, \hat{\Delta}, \tilde{r})$ and $\hat{\Delta} = \begin{cases} \hat{\Delta}_s & \text{if } \Delta^i = \Delta_s \text{ and } \phi(\theta_i^m) = t \\ \hat{\Delta}_0 & \text{otherwise.} \end{cases}$

Constraints (2.5.1)-(2.5.1.c) are the board's incentive compatibility constraints relative to its choice of messages, managerial compensation and disclosure commitment $(\hat{\theta}_b^h, \hat{\theta}_b^l, w_m, \phi)$, respectively. In particular, the board's choice of $(\hat{\theta}_b^h, \hat{\theta}_b^l, w_m, \phi)$ maximizes its expected compensation taking into account managerial incentives. Specifically, (2.5.1.a) ensures that the manager's choices of message and actions $(\hat{\theta}_m, e, \Delta)$ are incentive compatible, (2.5.1.b) imposes truth-telling on managerial messages and (2.5.1.c) states that managerial compensation contracts must be a non-decreasing function of firm output and subject to managerial limited liability. Constraint (2.5.2) corresponds to the board's truth-telling constraints and (2.5.3) states that board compensation contracts must also be a non-decreasing function of firm output and subject to limited liability.

The following lemma states the optimal compensation of the uninformed board:

Lemma 2.3.1. *The optimal compensation for uninformed board corresponds to* $w_b^{U*}(\hat{\theta}_b^m, \hat{\Delta}, \sigma_m, \tilde{r}) = (0, 0, 0)$ *for any* $(\hat{\theta}_b^m, \hat{\Delta}, \sigma_m)$.

Lemma 2.3.1 states that the uninformed board pay is independent of the firm's cash flows $\tilde{r}$. This feature, which greatly simplifies the analysis, implies that to the extent that shareholders do not want to induce board monitoring on θ, the board will act as a surrogate of the shareholders and will not be exposed to any other agency problem. In particular, the board will truthfully report $\hat{\theta}_m$, make a commitment $\phi^{U*}(\hat{\theta}_m) = t$ and offer the managerial compensation w_m^{U*} most desired by shareholders.[22] Lemma 2.3.1 also implies that the sequence of mechanism design problems that characterizes the shareholders' problem can be rewritten as a simple mechanism design problem.

In particular, this simpler problem can be described as one in which shareholders (who can observe Δ) designs managerial compensation

$$w_m'(\hat{\theta}_m, \tilde{r}) = \{u_m'(\hat{\theta}_m), m_m'(\hat{\theta}_m), d_m'(\hat{\theta}_m)\}$$

and commits to impose a risk choice $\Delta(\hat{\theta}_m) \in \{\Delta_0, \Delta_s\}$ as a function of the manager's message $\hat{\theta}_m$. Formally, the shareholders' problem can be rewritten as:

[22] While in this solution the board is indifferent in communicating its private information to shareholders, it is immediate to obtain a scheme in which the board strictly prefers such communications. For instance, $w_b^{U*}(\hat{\theta}_b^m, \hat{\Delta}_0, \sigma_m^h) = \begin{cases} \{\epsilon, \frac{\epsilon}{2}, 0\} & \text{if } (\hat{\theta}_b^m, \hat{\Delta}, \sigma_m) = (\hat{\theta}_h^b, \hat{\Delta}_0, \sigma_m^h) \\ \{\epsilon', \epsilon', \epsilon'\} & \text{if } (\hat{\theta}_b^m, \hat{\Delta}, \sigma_m) = (\hat{\theta}_l^b, \hat{\Delta}_0, \sigma_m^l) \\ \{0, 0, 0\} & \text{otherwise,} \end{cases}$
for $\epsilon, \epsilon' \simeq 0$ where σ_m^j $(j = h, l)$ corresponds to the managerial compensation that shareholders desire to offer to the manager who reports θ_j^m.

$$\max_{w'_m,\Delta} \; pV_s\left(w'_m, \Delta \mid \theta^m_h\right) + (1-p)V_s\left(w'_m, \Delta \mid \theta^m_l\right) \tag{2.9}$$

subject to

$$(\hat{\theta}^i_m, e^i) = \underset{\hat{\theta}_m, e}{\text{argmax}}\; V_m\left(\hat{\theta}_m, e \mid \theta_i, w'_m\right) \text{ for } i = h, l \tag{2.9.1}$$

$$\hat{\theta}^i_m = \theta^m_i \text{ for } i = h, l \tag{2.9.2}$$

$$u'_m(\hat{\theta}_m) \geq m'_m(\hat{\theta}_m) \geq d'_m(\hat{\theta}_m) \geq 0 \tag{2.9.3}$$

where, for i=h,l

$$\begin{aligned} V_s\left(w'_m, \Delta \mid \theta^m_i\right) = &\left(\frac{1}{3} + \theta_i e^i + \Delta(\theta^m_i)\right)\left[r^u - u'_m(\theta^m_i)\right] \\ &+ \left(\frac{1}{3} - 2\Delta(\theta^m_i)\right)\left[r^m - m'_m(\theta^m_i)\right] \\ &+ \left(\frac{1}{3} - \theta_i e^i + \Delta(\theta^m_i)\right)\left[r^d - d'_m(\theta^m_i)\right] \end{aligned} \tag{2.10}$$

and for j=h,l

$$\begin{aligned} V_m\left(\hat{\theta}_m, e \mid \theta_i, w'_m\right) = &\left(\frac{1}{3} + \theta_i e + \Delta(\hat{\theta}_m)\right) u'_m(\hat{\theta}_m) + \left(\frac{1}{3} - 2\Delta(\hat{\theta}_m)\right) m'_m(\hat{\theta}_m) \\ &+ \left(\frac{1}{3} - \theta_i e + \Delta(\hat{\theta}_m)\right) d'_m(\hat{\theta}_m) - \frac{\gamma_m e^2}{2}. \end{aligned} \tag{2.11}$$

To solve the problem, consider first the manager's optimization problem stated in (2.9.1). Given a menu of managerial compensation $w'_m(\hat{\theta}_m, \tilde{r})$, managerial effort depends on the managerial message $\hat{\theta}_m$ since such a message determines the relation between managerial compensation and the firm's cash flows. In particular, managerial effort denoted as $e(\hat{\theta}_m \mid \theta_i, w'_m)$ solves the first order condition of (2.11) and can be characterized as follows:[23]

[23]The use of first order approach is valid in this setting since the manager's maximization problem in (2.9.1) has a unique global maximum with respect to e (Grossman and Hart 1983).

Lemma 2.3.2. *A manager who observes θ_i $(i = h, l)$ and receives a menu of compensation contracts $w'_m(\hat{\theta}_m, \tilde{r})$ exerts effort*

$$e(\hat{\theta}_m \mid \theta_i, w'_m) = \frac{\theta_i \left[u'_m\left(\hat{\theta}_m\right) - d'_m\left(\hat{\theta}_m\right)\right]}{\gamma_m}. \tag{2.12}$$

Lemma 2.3.2 shows that the manager chooses higher effort as (i) the difference $u'_m(\hat{\theta}_m) - d'_m(\hat{\theta}_m)$ increases, (ii) the project's type θ is higher and (iii) the effort is less costly to the manager (γ_m decreases). By (2.12), I can substitute $e(\theta_i^m \mid \theta_i, w'_m)$ into e^i which corresponds to the optimal managerial effort choice for θ_i.

Proposition 2.3.3 summarizes the solution of the shareholders' problem:

Proposition 2.3.3. *In the uninformed board case: (i) the board receives flat compensation $w_b^{U*} = (0, 0, 0)$ and truthfully reports managerial risk choices, i.e., $\phi^{U*}(\hat{\theta}_m) = t$ and (ii) the manager receives the following compensation contract:*

$$w_m^{U*}(\hat{\theta}_m, \hat{\Delta}, \tilde{r}) = \begin{cases} \left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6(p\theta_h^2 + (1-p)\theta_l^2)}, 0, 0\right) & \textit{if } (\hat{\theta}_m, \hat{\Delta}) = (\theta_h^m, \hat{\Delta}_0), (\theta_l^m, \hat{\Delta}_0) \\ (0, 0, 0) & \textit{otherwise.} \end{cases}$$

Proposition 2.3.3 shows that shareholders induce the board to prevent the manager's choice of Δ_s which would decrease shareholder value by increasing the expected value of managerial compensation without increasing the expected value of the project. Proposition 2.3.3 also shows that the optimal managerial compensation ignores the information provided in the managerial message, i.e., it is a pooling contract with respect to θ. While separating compensation contracts (i.e., contracts that depend on the managerial message) would induce the manager to choose higher effort when he observes $\theta = \theta_h$, these contracts should inefficiently compensate the manager who observe θ_l when r^m or r^d is realized. In particular, the manager reveals $\theta = \theta_l$ only if the expected compensation from truthfully reporting θ_l^m is as large as the alternative compensation that corresponds to θ_h^m. Intuitively, for any separating contract that satisfies the manager's truth-telling constraints, shareholders find it more beneficial to withdraw the managerial compensation that corresponds to θ_l^m and alternately offer the managerial compensation that corresponds to θ_h^m as a pooling contract since this alternative contract induces higher managerial effort while providing the manager with truth-telling incentives.

2.4 Model analysis (II): Informed board

The *informed board case* considers the case in which shareholders design board compensation w_b to induce board monitoring on θ before the board chooses (w_m, ϕ). In what follows, I denote the sequence of optimal mechanisms chosen by shareholders and the board as $M^{I*} \equiv \{w_b^{I*}, (w_m^{I*}, \phi^{I*})\}$. Three features of the problem simplify the analysis. First, the board's mechanism design problem is simplified since board's monitoring incorporates θ to the board's information set. Thus, if the board does not monitor θ, managerial disclosures of private information about θ can affect board choices while if the board monitors, such managerial disclosures will have no effect on board choices. Second, the search of M^{I*} can be limited to the set of truth-telling mechanisms (on the equilibrium path) in which: (i) the board induces the manager to send a message $\hat{\theta}_m \in \{\theta_l^m, \theta_h^m\}$ that thuthfully reveals θ (when the board is uninformed about θ); (ii) shareholders induce the informed board to send a message $\hat{\theta}_b \in \{\theta_l^b, \theta_h^b\}$ which truthfully reveals its information about θ.[24]

Therefore, the sequence of optimal mechanisms chosen by shareholders and the board can be described by the triple

$$M^{I*} = \left[w_b^*(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}), \left(w_m^{I*}(\hat{\Delta}, \tilde{r}), \phi^{I*}\right), \left(w_m^{o*}(\hat{\theta}_m, \hat{\Delta}, \tilde{r}), \phi^{o*}(\hat{\theta}_m)\right)\right]$$

where:

1. $w_b^*(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}) \equiv \{u_b^*(\hat{\theta}_b, \hat{\Delta}, \sigma_m), m_b^*(\hat{\theta}_b, \hat{\Delta}, \sigma_m), d_b^*(\hat{\theta}_b, \hat{\Delta}, \sigma_m)\}$ describes the optimal board compensation.

2. $\left(w_m^{I*}(\hat{\Delta}, \tilde{r}), \phi^{I*}\right) \equiv \left(\{u_m^{I*}(\hat{\Delta}), m_m^{I*}(\hat{\Delta}), d_m^{I*}(\hat{\Delta})\}, \phi^{I*}\right)$ describes the optimal board's choices (on-the-equilibrium path) when the board monitors θ.

3. $\left(w_m^{o*}(\hat{\theta}_m, \hat{\Delta}, \tilde{r}), \phi^{o*}(\hat{\theta}_m)\right) \equiv \left(\{u_m^{o*}(\hat{\theta}_m, \hat{\Delta}), m_m^{o*}(\hat{\theta}_m, \hat{\Delta}), d_m^{o*}(\hat{\theta}_m, \hat{\Delta})\}, \phi^{o*}(\hat{\theta}_m)\right)$ describes the off-equilibrium path board's choices (i.e., choices taken if the board does not monitor θ).

Shareholders' problem consists of a nested sequence of optimization

[24]Without loss of generality I consider the case in which M^{I*} does not induce the uninformed board to admit that it is uninformed. On the equilibrium path, M^{I*} lead to the same compensation contracts with the optimal truth-telling mechanisms that induce the uninformed board to truthfully report about its information status, i.e., report $\hat{\theta}_b = \bar{\theta}^b$ and $\hat{\theta}_b^m = \hat{\theta}_i^b$ $(i = h, l)$ when it receives $\hat{\theta}_m = \theta_i^m$.

problems:

$$\max_{w_b} \; pV_s\left(w_b \mid \theta_h^b\right) + (1-p)V_s\left(w_b \mid \theta_l^b\right) \tag{2.13}$$

subject to

$$(\hat{\theta}_{ib}^i, w_m^i, \phi^i) = \underset{\hat{\theta}_b, w_m, \phi}{\text{argmax}} V_{ib}\left(\hat{\theta}_b, w_m, \phi \mid \theta_i, w_b\right) \text{ for } i = h, l \tag{2.13.1}$$

$$\text{s.t. } (e^i, \Delta^i) = \underset{e,\Delta}{\text{argmax}} V_m(e, \Delta \mid \theta_i, w_m, \phi) \text{ for } i = h, l \tag{2.13.1.a}$$

$$u_m(\hat{\Delta}) \geq m_m(\hat{\Delta}) \geq d_m(\hat{\Delta}) \geq 0, \tag{2.13.1.b}$$

$$\begin{aligned}(\hat{\theta}_{ub}^h, \hat{\theta}_{ub}^l, w_m^o, \phi^o) \\ = \underset{\hat{\theta}_b^h, \hat{\theta}_b^l, w_m, \phi}{\text{argmax}} \; pV_{ub}\left(\hat{\theta}_b^h, w_m, \phi \mid \theta_h^m, w_b\right) + (1-p)V_{ub}\left(\hat{\theta}_b^l, w_m, \phi \mid \theta_l^m, w_b\right)\end{aligned} \tag{2.13.2}$$

$$\text{s.t. } (\hat{\theta}_m^{i^o}, e^{i^o}, \Delta^{i^o}) = \underset{\hat{\theta}_m, e, \Delta}{\text{argmax}} \; V_m^o(\hat{\theta}_m, e, \Delta \mid \theta_i, w_m, \phi) \text{ for } i = h, l \tag{2.13.2.a}$$

$$\hat{\theta}_m^{i^o} = \theta_i^m \text{ for } i = h, l \tag{2.13.2.b}$$

$$u_m(\hat{\theta}_m, \hat{\Delta}) \geq m_m(\hat{\theta}_m, \hat{\Delta}) \geq d_m(\hat{\theta}_m, \hat{\Delta}) \geq 0, \tag{2.13.2.c}$$

$$\begin{aligned}&pV_{ib}(\hat{\theta}_{ib}^h, w_m^h, \phi^h \mid \theta_h, w_b) + (1-p)V_{ib}(\hat{\theta}_{ib}^l, w_m^l, \phi^l \mid \theta_l, w_b) - \gamma_b \\ &\quad \geq pV_{ub}\left(\hat{\theta}_{ub}^h, w_m^o, \phi^o \mid \theta_h^m, w_b\right) + (1-p)V_{ub}\left(\hat{\theta}_{ub}^l, w_m^o, \phi^o \mid \theta_l^m, w_b\right)\end{aligned} \tag{2.13.3}$$

$$\hat{\theta}_{ib}^i = \theta_i^b \text{ for } i = h, l \tag{2.13.4}$$

$$u_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m) \geq m_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m) \geq d_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m) \geq 0, \tag{2.13.5}$$

where

$$\begin{aligned}&V_m\left(e, \Delta \mid \theta_i, w_m, \phi\right) \\ &= \left(\frac{1}{3} + \theta_i e + \Delta\right) u_m(\hat{\Delta}) + \left(\frac{1}{3} - 2\Delta\right) m_m(\hat{\Delta}) + \left(\frac{1}{3} - \theta_i e + \Delta\right) d_m(\hat{\Delta}) - \frac{\gamma_m e^2}{2},\end{aligned} \tag{2.14}$$

for $\hat{\Delta} = \begin{cases} \hat{\Delta}_s & \text{if } \Delta = \Delta_s \text{ and } \phi = t \\ \hat{\Delta}_0 & \text{otherwise,} \end{cases}$

$V_m^o(\hat{\theta}_m, e, \Delta \mid \theta_i, w_m, \phi)$ and $V_{ub}\left(\hat{\theta}_b^i, w_m, \phi \mid \theta_i^m, w_b\right)$ are defined in (2.6) and (2.7), respectively,

$$
\begin{aligned}
&V_{ib}\left(\hat{\theta}_b, w_m, \phi \mid \theta_i, w_b\right) \\
&= \left(\frac{1}{3} + \theta_i e^i + \Delta^i\right) u_b\left(\hat{\theta}_b, \hat{\Delta}, \sigma_m\right) + \left(\frac{1}{3} - 2\Delta^i\right) m_b\left(\hat{\theta}_b, \hat{\Delta}, \sigma_m\right) \\
&+ \left(\frac{1}{3} - \theta_i e^i + \Delta^i\right) d_b\left(\hat{\theta}_b, \hat{\Delta}, \sigma_m\right),
\end{aligned}
\tag{2.15}
$$

and

$$
\begin{aligned}
&V_s\left(w_b \mid \theta_i^b\right) \\
&= \left(\frac{1}{3} + \theta_i e^i + \Delta^i\right)\left[r^u - u_b\left(\theta_i^b, \hat{\Delta}, \sigma_m\right) - u_m^i(\hat{\Delta})\right] \\
&+ \left(\frac{1}{3} - 2\Delta^i\right)\left[r^m - m_b\left(\theta_i^b, \hat{\Delta}, \sigma_m\right) - m_m^i(\hat{\Delta})\right] \\
&+ \left(\frac{1}{3} - \theta_i e^i + \Delta^i\right)\left[r^d - d_b\left(\theta_i^b, \hat{\Delta}, \sigma_m\right) - d_m^i(\hat{\Delta})\right]
\end{aligned}
\tag{2.16}
$$

for $\sigma_m = \{u_m^i(\hat{\Delta}), m_m^i(\hat{\Delta}), d_m^i(\hat{\Delta})\}$ and $\hat{\Delta} = \begin{cases} \hat{\Delta}_s & \text{if } \Delta^i = \Delta_s \text{ and } \phi^i = t \\ \hat{\Delta}_0 & \text{otherwise.} \end{cases}$

Constraints (2.13.1)-(2.13.1.b) are incentive compatibility constraints relative to the informed board's choices $(\hat{\theta}_b, w_m^I, \phi^I)$ and (2.13.2)-(2.13.2.c) are the incentive compatibility constraints relative to the uninformed board's choices $(\hat{\theta}_b, w_m^o, \phi^o)$. Notice that the optimization problems of the informed and uninformed board differ on the reliance on the managerial message $\hat{\theta}_m$. Specifically, the informed board only takes into account the effect of its choice on the managerial actions (e, Δ) specified in (2.13.1.a) but does not rely on the managerial message. In contrast, the uninformed board takes into account how its choices affect not only managerial actions (e, Δ) but also the managerial message $\hat{\theta}_m$. Furthermore, (2.13.2.a) ensures that the managerial choice of message and actions $(\hat{\theta}_m, e, \Delta)$ is incentive compatible and (2.13.2.b) that the managerial message is truthful. Constraints (2.13.1.b) and (2.13.2.c) state that managerial compensation contracts must be a non-decreasing function of firm output and subject to managerial limited liability. Analogously, (2.13.3) is the board monitoring incentive compatibility, (2.13.4) is the truth-telling constraint of the informed board and (2.13.5) limits board compensation contracts to be a non-decreasing function of firm output and subject to limited liability. The following lemma simplifies the analysis:

Lemma 2.4.1. *Without loss of generality, the search of optimal board compensation can be limited to contracts which specify managerial compensation* $(\sigma_m^h, \sigma_m^l) = \big((u_m^h, m_m^h, d_m^h), (u_m^l, m_m^l, d_m^l)\big)$ *and the board's reports* $\left(\hat{\Delta}^h, \hat{\Delta}^l\right) \in \left(\{\hat{\Delta}_0, \hat{\Delta}_s\}, \{\hat{\Delta}_0, \hat{\Delta}_s\}\right)$ *that lead to non-zero board pay as follows:*

$$w_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}) = \begin{cases} \left(u_b^h, m_b^h, d_b^h\right) & \text{if } (\hat{\theta}_b, \hat{\Delta}, \sigma_m) = (\theta_b^h, \hat{\Delta}^h, \sigma_m^h) \\ \left(u_b^l, m_b^l, d_b^l\right) & \text{if } (\hat{\theta}_b, \hat{\Delta}, \sigma_m) = (\theta_b^l, \hat{\Delta}^l, \sigma_m^l) \\ (0,0,0) & \text{otherwise,} \end{cases}$$

Lemma 2.4.1 implies that the search of optimal board compensation can be limited to contracts that award non-zero pay only to when the board's message $\hat{\theta}_b^i$ is in line with the board's choices $(\hat{\Delta}^i, \sigma_m^i)$, for $i = h, l$. As an example, consider a case in which lemma 2.4.1 limits non-zero board compensations to situations in which $\hat{\Delta}^h = \hat{\Delta}_s$, $\hat{\Delta}^l = \hat{\Delta}_0$, $\sigma_m^h = (100, 0, 0)$ and $\sigma_m^l = (50, 0, 0)$. In this case the board would be compensated only when: (i) it reports to shareholders $\hat{\theta}_b = \theta_h^b$, provides evidence $\hat{\Delta} = \hat{\Delta}_s$ and awards managerial compensation $\sigma_m^h = (100, 0, 0)$; or (ii) it reports $\hat{\theta}_b = \theta_l^b$, provides evidence $\hat{\Delta} = \hat{\Delta}_0$ and awards managerial compensation $\sigma_m^l = (50, 0, 0)$.

By virtue of lemma 2.4.1, I limit the search of the optimal mechanism M^{I*} to those mechanisms that include board compensation contracts of the form described in lemma 2.4.1. More specifically, I proceed by first characterizing the informed board choices (w_m^i, ϕ^i) for $i = h, l$ and the uninformed board choices (w_m^o, ϕ^o) and then solving for the optimal board compensation w_b^{I*} among those that induce the board to become informed i.e., to monitor θ.

2.4.1 Board's choices and managerial actions

2.4.1.1 Informed board's choices

Consider the informed board's choice of (w_m^I, ϕ^I) and the associated managerial choices (e, Δ). Lemma 2.4.1 shows that when the board sends a message to shareholders $\hat{\theta}_h$ (resp. $\hat{\theta}_l$), the board must report to shareholders $\hat{\Delta}^h$ (resp. $\hat{\Delta}^l$) and award managerial compensation σ_m^h (resp. σ_m^l) in order to receive a non-zero pay. Thus, I can search the informed board's optimal choice of w_m^I within the following forms of contracts:

Lemma 2.4.2. *An informed board that reports to shareholders $\hat{\theta}_b = \theta_j^b$ for $j \in \{h, l\}$ offers the manager:*

$$w_m^I(\hat{\Delta}, \tilde{r}) = \begin{cases} \sigma_m^j = (u_m^j, m_m^j, d_m^j) & \text{if } \hat{\Delta} = \hat{\Delta}^j \\ (0, 0, 0) & \text{otherwise,} \end{cases}$$

where $(\theta_j^b, \hat{\Delta}^j, \sigma_m^j)$ is the board's choice that makes board compensation non-zero as stated in Lemma 2.4.1.

Now consider the informed board's choice of ϕ^I. The disclosure commitment ϕ^I affects the managerial choice of Δ which in turn affects the board's report $\hat{\Delta}$. Since, as shown in lemma 2.4.1, the board receives non-zero compensation only when $\hat{\Delta}$ is consistent with $\hat{\theta}_b$, the board's decision on ϕ^I is affected by its message choice $\hat{\theta}_b$. Thus, I define ϕ_j^I $(j = h, l)$ as the informed board's optimal disclosure commitment when it chooses $\hat{\theta}_b = \theta_j^b$. To solve for ϕ_j^I, I consider the two mutually exclusive cases in which $\hat{\Delta}^j = \hat{\Delta}_s$ (i.e., the board should report to shareholders $\hat{\Delta}_s$ to receive non-zero pay) or $\hat{\Delta}^j = \hat{\Delta}_0$ (i.e., the board should report $\hat{\Delta}_0$ to receive non-zero pay).

If $\hat{\Delta}^j = \hat{\Delta}_s$, the board induces the manager to choose Δ_s since Δ_0 makes it impossible for the board to report $\hat{\Delta}_s$. To induce Δ_s, the board commits to a truthful report $\phi_j^I = t$ (i.e., to report $\hat{\Delta}_0$ only when the manager indeed chooses Δ_0) and offers the managerial compensation as characterized in lemma 2.4.2, i.e., the manager receives non-zero compensation only when he chooses Δ_s.

If $\hat{\Delta}^j = \hat{\Delta}_0$, lemma 2.4.2 implies that the board offers managerial compensation $w_m^I(\hat{\Delta}_0, \tilde{r}) = (u_m^j, m_m^j, d_m^j)$ and $w_m^I(\hat{\Delta}_s, \tilde{r}) = (0, 0, 0)$. While the board can report $\hat{\Delta}_0$ for any managerial choice of $\Delta \in \{\Delta_0, \Delta_s\}$, it still needs to design managerial compensation to induce the manager to choose the desirable alternative of Δ. In particular, when $u_m^j + d_m^j \leq 2m_m^j$, the risky choice Δ_s vis--vis Δ_0 decreases the expected value of managerial compensation $w_m^I(\hat{\Delta}_0, \tilde{r})$. Furthermore, since the board cannot falsely report $\hat{\Delta}_s$, the manager chooses Δ_0 for any ϕ_j^I. Alternatively, if $u_m^j + d_m^j > 2m_m^j$, the manager prefers Δ_s and will chooses it when the board commits to falsely reporting $\hat{\Delta}_0$, i.e., $\phi_j = f$. Therefore, ϕ_j^I can be used by the board to affect the managerial choice Δ.

Specifically, if the board compensation $w_b(\theta_j^b, \hat{\Delta}^j, \sigma_m^j, \tilde{r}) = (u_b^j, m_b^j, d_b^j)$ satisfies $u_b^j + d_b^j > 2m_b^j$, the board also prefers the managerial choice of Δ_s and therefore commits to a false report $\phi_j^I = f$. Otherwise, the board induces the manager to choose Δ_0 by committing to a truthful report $\phi_j^I = t$. The following lemma characterize the optimal disclosure commitment:

Proposition 2.4.3. *When the informed board sends message to shareholders $\hat{\theta}_b = \theta_j^b$ $(j = h, l)$, its optimal disclosure commitment*

$$\phi_j^I = \begin{cases} t & \textit{if (i) } \hat{\Delta}^j = \hat{\Delta}_s \textit{ or (ii) } \hat{\Delta}^j = \hat{\Delta}_0, C_m^j > 0 \textit{ and } C_b^j \le 0 \\ f & \textit{if } \hat{\Delta}^j = \hat{\Delta}_0, C_m^j > 0 \textit{ and } C_b^j > 0 \\ \in \{t, f\} & \textit{otherwise} \end{cases}$$

where $C_m^j \equiv u_m^j + d_m^j - 2m_m^j$ for managerial compensation $w_m^I(\hat{\Delta}^j, \tilde{r}) = (u_m^j, m_m^j, d_m^j)$ and $C_b^j \equiv u_b^j + d_b^j - 2m_b^j$ for board compensation $w_b(\theta_j^b, \hat{\Delta}^j, \sigma_m^j, \tilde{r}) = (u_b^j, m_b^j, d_b^j)$, respectively.

Proposition 2.4.3 shows that the board does not truthfully report about the manager's choice of Δ_s when $\hat{\Delta}^j = \hat{\Delta}_0$ and both C_m^j and C_b^j are strictly positive. Notice that C_m^j (resp. C_b^j) measures the convexity of managerial compensation (u_m^j, m_m^j, d_m^j) (resp. board compensation (u_b^j, m_b^j, d_b^j)) since, when $C_m^j > 0$ (resp. $C_b^j > 0$), the risky choice Δ_s increases the expected value of (u_m^j, m_m^j, d_m^j) (resp. (u_m^j, m_m^j, d_m^j)) relative to the risk-free choice Δ_0. Thus, proposition 2.4.3 captures the insight that a simultaneous award of convex compensation to the board and the manager can foster their collusive behavior at the expense of shareholders. Specifically, such a compensation structure induces the manager to choose Δ_s while providing incentives to the board to falsely report to shareholders $\hat{\Delta}_0$. Proposition 2.4.3 also suggests the following corollary with respect to the manager's optimal risk choice Δ^j.

Corollary 2.4.4. *When the informed board sends a message to shareholders $\hat{\theta}_b = \theta_j^b$ $(j = h, l)$, it induces the manager to choose $\Delta^j = \Delta_0$ if and only if (i) $\hat{\Delta}^j = \Delta_0$ and (ii) $C_m^j \leq 0$ or $C_b^j \leq 0$.*

Now consider the manager's effort choice induced by the informed board. When the board learns $\theta = \theta_i$ $(i = h, l)$ and reports to shareholders θ_j^b, it induces the managerial effort choice $e^{i,j}$ which solves the first order condition of (2.13.1.a) and can be characterized as follows:

Proposition 2.4.5. *When the board learns $\theta = \theta_i$ and reports to shareholders θ_j^b, the corresponding managerial compensation σ_m^j induces the managerial effort*

$$e^{i,j} = \frac{\theta_i(u_m^j - d_m^j)}{\gamma_m}. \tag{2.17}$$

From corollary 2.4.4 and proposition 2.4.5 it follows that the informed board's expected compensation that corresponds to the project's type θ_i and the message choice θ_j^b can be written as

$$V_b^{i,j}(w_b) = \left(\frac{1}{3} + \theta_i e^{i,j} + \Delta^j\right) u_b^j + \left(\frac{1}{3} - 2\Delta^j\right) m_b^j + \left(\frac{1}{3} - \theta_h e^{i,j} + \Delta^j\right) d_b^j. \tag{2.18}$$

2.4.1.2 Uninformed board's choices

To complete the analysis of the informed board actions it is necessary to describe what choice would be made by a board that remains uninformed. I refer to these off-equilibrium path choices as (w_m^o, ϕ^o). As in the choice of the informed board, the uninformed board's choice of w_m^o crucially hinges on the form of board compensation contracts stated in lemma 2.4.1. That is, when the board sends a message to shareholders $\hat{\theta}_h$ (resp. $\hat{\theta}_l$), the board should report to shareholders $\hat{\Delta}^h$ (resp. $\hat{\Delta}^l$) and award managerial compensation σ_m^h (resp. σ_m^l) in order to receive a non-zero pay. Furthermore, in contrast to the informed board, the uninformed board chooses (w_m^o, ϕ^o) to induce the manager to send a message $\hat{\theta}_m$ that truthfully reveals managerial private information about θ and after receiving $\hat{\theta}_m$ the uninformed board subsequently sends a message to shareholders $\hat{\theta}_b$. To facilitate the presentation, I define $(\hat{\theta}_{ub}^h, \hat{\theta}_{ub}^l) \in (\{\theta_h^b, \theta_l^b\}, \{\theta_h^b, \theta_l^b\})$ as the uninformed board's message choice when it receives a managerial message $\hat{\theta}_m = \theta_h^m$ and θ_l^m, respectively.[25]

In what follows, I solve the shareholders' problem by assuming that the uninformed board's optimal message choice does not depend on the managerial message, i.e., $\hat{\theta}_{ub}^h = \hat{\theta}_{ub}^l \equiv \hat{\theta}_{ub}$ and after solving the problem, check the conditions in which this assumption indeed holds.[26] Lemma 2.4.1 implies that under this assumption the uninformed board receives non-zero pay only when $\left(\hat{\theta}_{ub}, \hat{\Delta}, w_m^o(\theta_m^i, \hat{\Delta}, \tilde{r})\right) = \left(\theta_h^b, \hat{\Delta}^h, \sigma_m^h\right)$ or $\left(\theta_l^b, \hat{\Delta}^l, \sigma_m^l\right)$ for $i = h, l$ and therefore the search of optimal w_m^o can be limited to the following forms of

[25]For instance, $(\hat{\theta}_{ub}^h, \hat{\theta}_{ub}^l) = (\theta_h^b, \theta_l^b)$ refers to the case in which the board reports to shareholders θ_h^b (resp. θ_l^b) when it receives managerial message $\hat{\theta}_m = \theta_h^m$ (resp. θ_l^m).

[26]As it turns out, this assumption holds in relaxed conditions, and furthermore, the optimal mechanisms obtained under this assumption illustrate the main insights without loss of generality.

contracts:

Lemma 2.4.6. *An uninformed board that reports to shareholders $\hat{\theta}_{ub} = \theta^b_j$ for $j \in \{h, l\}$ offers the manager:*

$$w^o_m(\hat{\theta}_m, \hat{\Delta}, \tilde{r}) = \begin{cases} \sigma^j_m = (u^j_m, m^j_m, d^j_m) & \textit{if } (\hat{\theta}_m, \hat{\Delta}) = (\theta^m_h, \hat{\Delta}^j) \textit{ or } (\theta^m_l, \hat{\Delta}^j) \\ (0,0,0) & \textit{otherwise,} \end{cases}$$

where $(\theta^b_h, \hat{\Delta}^h, \sigma^h_m)$ and $(\theta^b_l, \hat{\Delta}^l, \sigma^l_m)$ are the board's choices that make the board compensation non-zero as stated in Lemma 2.4.1.

With respect to the uninformed board's disclosure commitment $\phi^o(\hat{\theta}_m)$, in contrast to the informed board, the uninformed board chooses $\phi^o(\hat{\theta}_m)$ taking into account its effect not only on the managerial choice of Δ but also on the managerial message choice $\hat{\theta}_m$. In particular, the optimal ϕ^o should induce the manager's truthful report about θ.[27] Moreover, since the project's type θ does not affect the managerial choice of Δ, the optimal ϕ^o needs not be contingent upon $\hat{\theta}_m$ and can be characterized as follows:

Proposition 2.4.7. *When the uninformed board reports to shareholders $\hat{\theta}_{ub} = \theta^b_j$ for $j \in \{h, l\}$, its optimal disclosure commitment is as follows:*

$$\phi^o(\hat{\theta}^m_h) = \phi^o(\hat{\theta}^m_l) = \begin{cases} t & \textit{if (i) } \hat{\Delta}^j = \hat{\Delta}_s \textit{ or} \\ & \quad \textit{(ii) } \hat{\Delta}^j = \hat{\Delta}_0, C^j_m > 0 \textit{ and } C^j_b \leq 0 \\ f & \textit{if } \hat{\Delta}^j = \hat{\Delta}_0, C^j_m > 0 \textit{ and } C^j_b > 0 \\ \in \{t, f\} & \textit{otherwise} \end{cases}$$

[27] As stated in lemma 2.4.6, the optimal w^o_m chosen by the uninformed board is not contingent on $\hat{\theta}_m$.

where $C_m^j \equiv u_m^j + d_m^j - 2m_m^j$ corresponds to the convexity of managerial compensation $w_m^o(\hat{\theta}_h^m, \hat{\Delta}^j, \tilde{r}) = w_m^o(\hat{\theta}_l^m, \hat{\Delta}^j, \tilde{r}) = (u_m^j, m_m^j, d_m^j)$ and $C_b^j \equiv u_b^j + d_b^j - 2m_b^j$ to the convexity of board compensation $w_b(\theta_j^b, \hat{\Delta}^j, \sigma_m^j, \tilde{r}) = (u_b^j, m_b^j, d_b^j)$, respectively.

Proposition 2.4.7 is analogous to the informed board's optimal commitment stated in proposition 2.4.3. As before, the uninformed board commits to the manager to falsely reporting $\hat{\Delta}$ when both managerial compensation and board compensation are convex (i.e., $C_m^j > 0$ and $C_b^j > 0$ for $j = h, l$) and shareholders induce the board to report $\hat{\Delta}_0$. The following corollary is immediate:

Corollary 2.4.8. *When the informed board sends a message to shareholders $\hat{\theta}_{ub} = \theta_j^b$ $(j = h, l)$, it induces the manager to choose $\Delta^j = \Delta_0$ if and only if (i) $\hat{\Delta}^j = \Delta_0$ and (ii) $C_m^j \leq 0$ or $C_b^j \leq 0$.*

Finally, consider the managerial effort choice induced by the uninformed board. The uninformed board offers the manager (w_m^o, ϕ^o) which is not contingent upon the managerial message $\hat{\theta}_m$ and, thus, which induces the manager to truthfully report about $\theta = \theta_i$ $(i = h, l)$, i.e., $\hat{\theta}_m = \theta_i^m$. Therefore, when the uninformed board receives $\hat{\theta}_m = \theta_i^m$ and subsequently reports to shareholders $\hat{\theta}_{ub}^i = \theta_j^b$ $(j = h, l)$, the corresponding managerial compensation σ_m^j induces the managerial effort choice as follows:

Proposition 2.4.9. *When the uninformed board receives θ_i^m for $i \in \{h, l\}$ and subsequently reports to shareholders θ_j^b for $j \in \{h, l\}$, the corresponding* *managerial compensation σ_m^j induces the managerial effort*

$$e^{i,j} = \frac{\theta_i(u_m^j - d_m^j)}{\gamma_m}. \tag{2.19}$$

Corollary 2.4.8 and proposition 2.4.9 imply that when the uninformed board receives $\hat{\theta}_m = \theta_i^m$ $(i = h, l)$ and reports to shareholders $\hat{\theta}_m = \theta_j^b$ $(j = h, l)$, the managerial actions (e, Δ) induced by the uninformed board equals the managerial actions induced by the informed board who learns θ_i and reports to shareholders θ_j^b, and thus, the uninformed board's expected compensation corresponds to $V_b^{i,j}$ defined in (2.18).

2.4.2 Optimal mechanism M^{I*}

The shareholders' problem can be simplified by using the board's optimal choices and the associated managerial actions characterized in section 2.4.1.1 and 2.4.1.2. First, I can rewrite the board's truth-telling constraint (2.13.4) as follows:

$$V_b^{h,h}(w_b) \geq V_b^{h,l}(w_b) \tag{2.20}$$

$$V_b^{l,l}(w_b) \geq V_b^{l,h}(w_b), \tag{2.21}$$

where $V_b^{i,j}$ defined in (2.18). Second, the board's expected compensation from reporting $\hat{\theta}_{ub} = \theta_b^j$ $(j \in \{h, l\})$ without monitoring θ is $pV_b^{h,j}(w_b) + (1-p)V_b^{l,j}(w_b)$ while its expected compensation from monitoring and truthfully reporting θ is $pV_b^{h,h}(w_b)+(1-p)V_b^{l,l}(w_b)$. Thus, the board's monitoring incentive compatibility condition (2.13.3) can be rewritten as:

$$pV_b^{h,h}(w_b) + (1-p)V_b^{l,l}(w_b) - \gamma_b \geq pV_b^{h,h}(w_b) + (1-p)V_b^{l,h}(w_b) \tag{2.22}$$

$$pV_b^{h,h}(w_b) + (1-p)V_b^{l,l}(w_b) - \gamma_b \geq pV_b^{h,l}(w_b) + (1-p)V_b^{l,l}(w_b). \tag{2.23}$$

Notice that (2.20) and (2.21) are necessary conditions for (2.23) and (2.22), respectively. In other words, any board compensation that induces the board to monitor θ will always induce the board to truthfully reveal θ after monitoring. Using the board compensation arrangements specified in lemma 2.4.1 and the associated managerial actions (e, Δ) characterized in corollary 2.4.4 and proposition 2.4.5, the shareholders' problem can be written as:

$$\max_{\substack{\sigma_b^h,\sigma_b^l,\sigma_m^h,\\ \sigma_m^l,\hat{\Delta}^h,\hat{\Delta}^l}} \; p\left[\left(\frac{1}{3}+e^{h,h}+\Delta^h\right)u_s^h + \left(\frac{1}{3}-2\Delta^h\right)m_s^h + \left(\frac{1}{3}-e^{l,l}+\Delta^h\right)d_s^h\right]$$

$$+ (1-p)\left[\left(\frac{1}{3}+e^{l,l}+\Delta^l\right)u_s^l + \left(\frac{1}{3}-2\Delta^l\right)m_s^l + \left(\frac{1}{3}-e^{l,l}+\Delta^l\right)d_s^l\right] \tag{2.24}$$

subject to

$$\left(\frac{1}{3}+e^{l,l}+\Delta^h\right)u_b^l + \left(\frac{1}{3}-2\Delta^l\right)m_b^l + \left(\frac{1}{3}-e^{l,l}+\Delta^l\right)d_b^l - \frac{\gamma_b}{1-p}$$

$$\geq \left(\frac{1}{3}+e^{l,h}+\Delta^l\right)u_b^h + \left(\frac{1}{3}-2\Delta^h\right)m_b^h + \left(\frac{1}{3}-e^{l,h}+\Delta^h\right)d_b^h \tag{2.25}$$

$$\left(\frac{1}{3}+e^{h,h}+\Delta^h\right)u_b^h + \left(\frac{1}{3}-2\Delta^h\right)m_b^h + \left(\frac{1}{3}-e^{h,h}+\Delta^h\right)d_b^h - \frac{\gamma_b}{p}$$

$$\geq \left(\frac{1}{3}+e^{h,l}+\Delta^l\right)u_b^l + \left(\frac{1}{3}-2\Delta^l\right)m_b^l + \left(\frac{1}{3}-e^{h,l}+\Delta^l\right)d_b^l \tag{2.26}$$

$$u_b^i \geq m_b^i \geq d_b^i \geq 0 \text{ for } i = h, l \tag{2.27}$$

$$u_m^i \geq m_m^i \geq d_m^i \geq 0 \text{ for } i = h, l \tag{2.28}$$

where

1. $\sigma_m^i = (u_m^i, m_m^i, d_m^i)$: managerial compensation that shareholders induce

the board to offer when the board sends a message $\hat{\theta}_b = \theta_i^b$ for $i = h, l$.

2. $\hat{\Delta}^i$: the alternative of $\hat{\Delta}$ that shareholders induce the board to report when the board reports $\hat{\theta}_b = \theta_i^b$ for $i = h, l$.

3. $\sigma_b^i = (u_b^i, m_b^i, d_b^i)$: board compensation when the board chooses $(\hat{\theta}_b, \hat{\Delta}, \sigma_m) = (\theta_i^b, \hat{\Delta}^i, \sigma_m^i)$ for $i = h, l$.

4. $e^{i,j} = \frac{\theta_i^2 (u_m^j - d_m^j)}{\gamma_m}$: the managerial choice of e when the project type is $\theta = \theta_i$ and the board reports $\hat{\theta}_b = \theta_j^b$ for $i, j = h, l$.

5. $\Delta^i = \begin{cases} \Delta_0 & \text{if (i) } \hat{\Delta}^i = \Delta_0 \text{ and } u_m^i + d_m^i - 2m_m^i < 0 \\ & \text{or (ii)} \hat{\Delta}^i = \Delta_0 \text{ and } u_b^i + d_b^i - 2m_b^i < 0 \\ \Delta_s & \text{otherwise} \end{cases}$
corresponds to the managerial choice of Δ induced by the board when the board reports $\hat{\theta}_b = \theta_i^b$ for $i = h, l$.

Constraints (2.25) and (2.26) are derived from the board's monitoring incentive compatibility constraints (2.22) and (2.23), respectively. Constraints (2.27) and (2.28) ensure that both managerial and board compensation are non-decreasing function of firm's cash flows and subject to the limited liability. The optimal board and managerial compensation that solve the shareholders' problem is characterized as follows:

Proposition 2.4.10. *The optimal board and managerial compensation contracts are formed as* $\left[\sigma_b^{l^*}, \sigma_m^{l^*}\right] = \left[\left(f_b^{l^*}, f_b^{l^*}, f_b^{l^*}\right), \left(u_m^{l^*}, 0, 0\right)\right]$. *Furthermore, de-*

pending on parameter values, three cases can arise with respect to $\left[\sigma_b^{h^*}, \sigma_m^{h^*}\right]$*:*

Case 1: $[\sigma_b^{h^*}, \sigma_m^{h^*}] = [(u_b^{h^*}, 0, 0), (u_m^{h^*}, 0, 0)]$

Case 2: $[\sigma_b^{h^*}, \sigma_m^{h^*}] = [(u_b^{h^*}, \frac{u_b^{h^*}}{2}, 0), (u_m^{h^*}, 0, 0)]$

Case 3: $[\sigma_b^{h^*}, \sigma_m^{h^*}] = [(u_b^{h^*}, 0, 0), (u_m^{h^*}, \frac{u_m^{h^*}}{2}, 0)]$.

Proposition 2.4.10 shows three key features of the optimal board and managerial compensation. First, the optimal board compensation $\sigma_b^{h^*}$ and $\sigma_b^{l^*}$ exhibit contrasting forms: while $\sigma_b^{h^*}$ corresponds to a performance-based pay, i.e., an increasing function of the firm's cash flows, $\sigma_b^{l^*}$ corresponds to a fixed wage. These contrasting forms of contracts provide the board's incentives to monitor θ. Specifically, relative to the project with $\theta = \theta_l$, the project with $\theta = \theta_h$ is more likely to yield r^u and less likely to yield r^d. Therefore, in the absence of the constraint (2.27), the optimal board compensation that induces the board's monitoring on θ consists of σ_b^h which compensates only for the realization of r^u and σ_b^l which compensates only for r^d. While (2.27) ensures that $\sigma_b^{l^*}$ corresponds to a fixed wage rather than a decreasing function of the firm's cash flows, the constraint does not change the main insight that the optimal board compensation awards the board with higher performance-based compensation when the board reports $\hat{\theta}_b = \theta_h^b$.

Second, proposition 2.4.10 shows that the optimal managerial compensation $\sigma_m^{h^*}$ and $\sigma_m^{l^*}$ feature a performance-based pay structure. Intuitively, shareholders induce the board to offer the minimum managerial compensation which induces certain managerial choices of (e, Δ). As shown in proposition

2.4.5, to induce the managerial effort, optimal managerial compensation $\sigma_m^{i^*}$ $(i = h, l)$ should feature that $u_m^{i^*} - d_m^{i^*} > 0$.

Finally, proposition 2.4.10 states that depending on the parameter values, the optimal board and managerial compensation that corresponds to the board's message θ_h^b, i.e., $\left[\sigma_b^{h^*}, \sigma_m^{h^*}\right]$ has different forms. Intuitively, the optimal form of $\left[\sigma_b^{h^*}, \sigma_m^{h^*}\right]$ is related to the optimal managerial risk choice Δ^{h^*}. While the convex compensation $\sigma_b^{h^*} = (u_b^{h^*}, 0, 0)$ and $\sigma_m^{h^*} = (u_m^{h^*}, 0, 0)$ provide board incentives to monitor θ and managerial incentives to put effort, respectively, the simultaneous award of convex compensation induces the managerial choice of Δ_s. Specifically, corollary 2.4.4 states that to induce the managerial choice $\Delta^{h^*} = \Delta_0$, either $\sigma_m^{h^*}$ or $\sigma_b^{h^*}$ should feature a (weakly) negative convexity, i.e., $u_m^{h^*} + d_m^{h^*} - 2m_m^{h^*} \leq 0$ or $u_b^{h^*} + d_b^{h^*} - 2m_b^{h^*} \leq 0$. Since the compensation for r^m does not affect the managerial effort choice or the board's monitoring on θ, the optimal compensation structure that induces the managerial choice $\Delta^{h^*} = \Delta_0$ should compensate the board or the manager for r_m just enough to make $\sigma_b^{h^*}$ or $\sigma_m^{h^*}$, but not both, exhibit zero convexity.

It is noteworthy that by contrast $\left[\sigma_b^{l^*}, \sigma_m^{l^*}\right]$ exhibits a fixed wage and convex compensation, respectively, since the fixed wage induces the board to monitor and truthfully reveal the managerial choice of Δ_s. From these observations, the following corollary which characterizes the optimal managerial risk choice $\left(\Delta^{h^*}, \Delta^{l^*}\right)$ is immediate.

Corollary 2.4.11. *The optimal managerial risk choice* $\left(\Delta^{h^*}, \Delta^{l^*}\right) = (\Delta_s, \Delta_0)$ *in case 1 and* (Δ_0, Δ_0) *in other cases.*

For the future reference, I refer to case 1 as *speculation case* since the manager optimally chooses Δ_s when the board reports θ_b^h, case 2 as *disciplinary board case* since non-convex board compensation $\sigma_b^{h^*} = (u_b^{h^*}, u_b^{h^*}/2, 0)$ provides the board with incentives to induce the managerial choice $\Delta^h = \Delta_0$ and case 3 as *contracting board case* since in this case the board plays a meaningful role only in the design of managerial compensation (i.e., monitoring θ) and managerial choice $\Delta^h = \Delta_0$ is induced by the non-convex managerial compensation $\sigma_m^{h^*} = (u_m^{h^*}, u_m^{h^*}/2, 0)$.

Proposition 2.4.10 also implies that the full description of the optimal compensation structure requires to find two managerial compensation components $\left(u_m^{h^*}, u_m^{l^*}\right)$ and two board compensation components $\left(u_b^{h^*}, f_b^{l^*}\right)$. For simplicity, I denote by $\left[\left(u_{m,s}^{h^*}, u_{m,s}^{l^*}\right), \left(u_{b,s}^{h^*}, f_{b,s}^{l^*}\right)\right]$ the optimal compensation components in the *speculation case*, $\left[\left(u_{m,d}^{h^*}, u_{m,d}^{l^*}\right), \left(u_{b,d}^{h^*}, f_{b,d}^{l^*}\right)\right]$ in the *disciplinary board case* and by $\left[\left(u_{m,d}^{h^*}, u_{m,d}^{l^*}\right), \left(u_{b,c}^{h^*}, f_{b,c}^{l^*}\right)\right]$ in the *contracting board case*. The following proposition characterizes the optimal compensation components in each case.

Proposition 2.4.12. *The optimal compensation structure in each case can be described by the following compensation components.*

1. *speculation case:*

$$\left[u^{l^*}_{m,s}, u^{h^*}_{b,s}, f^{l^*}_{b,s}\right] =$$
$$\left[\frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}, \frac{\gamma_b\gamma_m}{p(1-p)(\theta_h^2 - \theta_l^2)u^{h^*}_{m,s}}, \left(\frac{1}{3} + \frac{\theta_l^2 u^{h^*}_{m,s}}{\gamma_m} + \Delta_s\right) u^{h^*}_{b,s} + \frac{\gamma_b}{1-p}\right],$$

where $u^{h^*}_{m,s}$ *solves*

$$\frac{p\theta_h^2(r^u - r^d)}{\gamma_m} - p\left[\left(\frac{1}{3} + \Delta_s\right) + \frac{2\theta_h^2 u^{h^*}_{m,s}}{\gamma_m}\right] + \left(\frac{1}{3} + \Delta_s\right)\frac{\gamma_b\gamma_m}{p(1-p)(\theta_h^2 - \theta_l^2)(u^{h^*}_{m,s})^2} = 0$$

2. *disciplinary board case:*

$$\left[u^{l^*}_{m,d}, u^{h^*}_{b,d}, f^{l^*}_{b,d}\right] =$$
$$\left[\frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}, \frac{\gamma_b\gamma_m}{p(1-p)(\theta_h^2 - \theta_l^2)u^{h^*}_{m,d}}, \left(\frac{1}{2} + \frac{\theta_l^2 u^{h^*}_{m,d}}{\gamma_m}\right) u^{h^*}_{b,d} + \frac{\gamma_b}{1-p}\right],$$

where $u^{h^*}_{m,d}$ *solves*

$$\frac{p\theta_h^2(r^u - r^d)}{\gamma_m} - p\left[\frac{1}{3} + \frac{2\theta_h^2 u^{h^*}_{m,d}}{\gamma_m}\right] + \frac{\gamma_b\gamma_m}{2p(1-p)(\theta_h^2 - \theta_l^2)(u^{h^*}_{m,d})^2} = 0$$

3. *contracting board case:*

$$\left[u^{l^*}_{m,c}, u^{h^*}_{b,c}, f^{l^*}_{b,c}\right] =$$
$$\left[\frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}, \frac{\gamma_b\gamma_m}{p(1-p)(\theta_h^2 - \theta_l^2)u^{h^*}_{m,c}}, \left(\frac{1}{3} + \frac{\theta_l^2 u^{h^*}_{m,c}}{\gamma_m}\right) u^{h^*}_{b,c} + \frac{\gamma_b}{1-p}\right],$$

where $u^{h^*}_{m,c}$ *solves*

$$\frac{p\theta_h^2(r^u - r^d)}{\gamma_m} - p\left[\frac{1}{2} + \frac{2\theta_h^2 u^{h^*}_{m,c}}{\gamma_m}\right] + \frac{\gamma_b\gamma_m}{3p(1-p)(\theta_h^2 - \theta_l^2)(u^{h^*}_{m,c})^2} = 0.$$

Proposition 2.4.12 shows that there are common features of the optimal managerial and board compensation structure that appear in all three cases. First, for any given parameter values, u^{l*}_m is the same in all three cases. Second, the board and managerial compensation $(u^{h^*}_b, u^{h^*}_m)$ exhibit substitutability, i.e., the increase in $u_m^{h^*}$ leads to the decrease in $u_b^{h^*}$. Finally, awarding higher $u_b^{h^*}$ to the board also increases the board's fixed wage $f_b^{l^*}$.

On the other hand, proposition 2.4.12 also shows that for given parameter values, the three cases differ in the size of optimal compensation components $u_b^{h^*}$, $f_b^{l^*}$ and $u_m^{h^*}$. In particular, the following proposition compares the size of the compensation components in each case.

Proposition 2.4.13. *For any parameter values,*

1. *Board compensation feature* $u_{b,c}^{h^*} > u_{b,s}^{h^*} > u_{b,d}^{h^*}$ *and* $f_{b,d}^{l^*} > f_{b,s}^{l^*} > f_{b,c}^{l^*}$
2. *Managerial compensation feature* $u_{m,d}^{h^*} > u_{m,s}^{h^*} > u_{m,c}^{h^*} > u_{m,d}^{l^*} (= u_{m,s}^{l^*} = u_{m,c}^{l^*})$.

Proposition 2.4.13 states that the performance-based managerial compensation $u_m^{h^*}$ is the highest in the *disciplinary board case* and the lowest in the *contracting board case*. In contrast, the performance-based board compensation $u_b^{h^*}$ is the highest in the *contracting board case* and the lowest in the *disciplinary board case*. This result is intuitive. As implied by proposition 2.4.10, shareholders must award non-convex compensation to the manager or the board in order to induce the managerial choice of $\Delta^h = \Delta_0$. Compensation for r^m, however, creates inefficiencies since it does not affect the board's incentive to monitor θ or the managerial incentive to put effort. In the *disciplinary board case*, the non-convexity of board compensation $\sigma_b^{h^*}$ limits the size of $u_{b,d}^{h^*}$ but instead shareholders can induce higher managerial effort than in the other two cases since the managerial risk choice is controlled by the board. On the other hand, in the *contracting board case* the non-convexity of managerial compensation $\sigma_{m,c}^{h^*}$ limits the size of $u_{m,c}^{h^*}$.

Proposition 2.4.13 also shows that fixed wage to the board $f_b^{l^*}$ is the highest in the *disciplinary board case* and the lowest in the *contracting board case*. In the *disciplinary board case*, the expected value of board compensation $\sigma_b^{h^*}$ is greater than the corresponding board compensation of other cases since it compensates for r^m and thus shareholders need to award higher fixed wage in order to induce the board to monitor and truthfully report about θ. Finally, proposition 2.4.13 states that in all three cases, the managerial compensation features $u_m^{h^*} > u_m^{l^*}$, i.e., the manager receives higher performance-based compensation when the board reports $\hat{\theta}_b = \theta_h^b$ than when it reports θ_l^b. Intuitively, shareholders delegate the managerial compensation to the board in order to use the board's private information about θ and to induce higher managerial effort when $\theta = \theta_h$.

So far, I have characterized the possible forms of optimal compensation contracts. In section 2.5, I search the optimal managerial and board compensation by comparing shareholder values in *uninformed board case* and the three cases that arises in *informed board case* and then analyze how the key parameters affect the compensation structure.

2.5 Optimal compensation structure

Shareholder value in each case can be written as follows:

Uninformed board case:

$$V_0 + \frac{V_\theta}{\gamma_m}\left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6V_\theta}\right)^2, \tag{2.29}$$

Speculation case:

$$V_0 - \left(\frac{1}{3} + \Delta_s\right)\frac{2\gamma_b}{D_\theta u_{m,s}^{h^*}} + \frac{p\theta_h^2 (u_{m,s}^{h^*})^2}{\gamma_m} - \left(\frac{V_\theta}{\gamma_m D_\theta} + 1\right)\gamma_b + \frac{(1-p)\theta_l^2}{\gamma_m}\left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}\right)^2, \tag{2.30}$$

Disciplinary board case:

$$V_0 - \frac{\gamma_b}{D_\theta u_{m,d}^{h^*}} + \frac{p\theta_h^2 (u_{m,d}^{h^*})^2}{\gamma_m} - \left(\frac{V_\theta}{\gamma_m D_\theta} + 1\right)\gamma_b + \frac{(1-p)\theta_l^2}{\gamma_m}\left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}\right)^2, \tag{2.31}$$

Contracting board case:

$$V_0 - \frac{2\gamma_b}{3D_\theta u_{m,c}^{h^*}} + \frac{p\theta_h^2 (u_{m,c}^{h^*})^2}{\gamma_m} - \left(\frac{V_\theta}{\gamma_m D_\theta} + 1\right)\gamma_b + \frac{(1-p)\theta_l^2}{\gamma_m}\left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}\right)^2, \tag{2.32}$$

where $(u_{m,s}^{h^*}, u_{m,c}^{h^*}, u_{m,c}^{h^*})$ are as in proposition 2.4.12, $V_0 = \frac{1}{3}(r^u + r^m + r^d)$, $D_\theta \equiv \frac{p(1-p)(\theta_h^2 - \theta_l^2)}{\gamma_m}$ and $V_\theta \equiv (p\theta_h^2 + (1-p)\theta_l^2)$. The globally optimal mechanism corresponds to the case in which shareholders value is maximized. In the rest of this section, I first perform comparative statics with respect to some key parameters and then I discuss the results, and in particular, develop testable hypotheses relative to the optimal managerial and board compensation structure.

2.5.1 Comparative statics

For comparative statics, I consider four key parameters, namely, (i) Δ_s which measures the effect of managerial risk-seeking activities on the firm's cash flow risks, (ii) γ_b which measures the board monitoring costs, (iii) D_θ which measures the variability in the project quality θ and (iv) $D_r \equiv r^u - r^d$

which measures the size of value enhancement by managerial effort. The following proposition shows that each of key parameters $(\Delta_s, \gamma_b, D_\theta, D_r)$ monotonically affects the shareholder value in the *uninformed board case* relative to *the informed board case.*

Proposition 2.5.1. *Other things equal, (i) higher Δ_s, (ii) higher γ_b (iii) lower D_θ and (iv) lower D_r make shareholder value larger in uninformed board case relative to informed board case.*

Proposition 2.5.1 is intuitive. When managerial risk choice substantially affects the firm's cash flow risks (i.e., Δ_s is larger), shareholders are willing to make the board compensation flat as in the *uninformed board case* in order to the board monitoring on managerial risk choice. On the other hand, when the board monitoring on θ is too costly (i.e., γ_b is too high), shareholders do not afford to induce the board to monitor θ before designing the managerial compensation. Finally, when the variability in project quality (D_θ) and the firm value enhancement by managerial effort (i.e., D_r) are sufficiently small, shareholders' benefit from incorporating the board information on θ into the design of managerial compensation cannot offset the costs that shareholders incur to induce the board monitoring.

In the rest of this section, I focus on the three cases in which the board monitors θ since the key implications on the joint compensation structure arise in these cases.[28] In contrast to the *disciplinary board case* and the *contract-*

[28]This also reflects the realistic feature that the board takes the full responsibility for the

ing board case, the *speculation case* is subject to two inefficiencies emerging from the manager's choice of Δ_s. The risky choice increases the manager's expected compensation without creating incentive for managerial effort and it also increases the expected board's compensation without affecting the board's incentive to monitor θ. Intuitively, these inefficiencies increase in the size of Δ_s. Thus,

Proposition 2.5.2. *For each parameter values, there exists* $\bar{\Delta}_s > 0$ *such that speculation case becomes equilibrium if and only if* $\Delta_s \leq \bar{\Delta}_s$.

On the other hand, the inefficiencies that arise in the other two cases are associated with the non-convexity of board compensation or managerial compensation. Specifically, in the *disciplinary board case*, the board compensation $\sigma_b^{h^*}$ pays for r^m without providing the board with incentive to monitor θ but instead the corresponding managerial compensation $\sigma_m^{h^*}$ awards higher performance-based compensation and, thus, induces higher managerial effort choice. In the *contracting board case*, by contrast, the managerial compensation $\sigma_m^{h^*}$ needs to be non-convex and, thus, awards relatively lower performance-based compensation which leads to lower managerial effort choice. The following proposition shows how these inefficiencies that emerge from the three *informed board* cases are affected by the key parameters in this analysis:

Proposition 2.5.3. *For each parameter values, there exists* $\bar{\gamma}_b \geq 0$, $\bar{D}_\theta \geq 0$ *and* $\bar{D}_r \geq 0$ *such that the globally optimal mechanism belongs to the disci-*

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design of managerial compensation in practice.

plinary board case when, other things equal, (i) $\gamma_b < \bar{\gamma}_b$*, (ii)* $D_\theta > \bar{D}_\theta$ *and (iii)* $r^u - r^d > \bar{D}_r$ *is higher.*

In the *disciplinary board regime*, awarding performance-based compensation to the board is costly and therefore shareholders can induce the board to monitor θ only when the monitoring cost γ_b is sufficiently low. On the other hand, when the variability in the project quality is large (i.e., D_θ is higher), the board requires lower level of performance-based compensation to monitor θ. When the board does not monitor θ before choosing the managerial compensation, it may receive performance-based compensation for unproductive projects or fixed wage for productive projects. The larger variability in the project quality, however, significantly reduce the expected value of board compensation misaligned with the project type and thus induces the board to monitor the type even at lower level of performance-based compensation. Finally, when D_r is high, the managerial effort increases the firm value more efficiently and thus the optimal compensation structure belongs to *disciplinary board case* in which the managerial compensation features the highest level of performance-based compensation.

2.5.2 Discussion

The previous analysis provides a number of insights relative to the optimal managerial and board compensation. First, it shows that in the *informed board* case (i.e., when board are active monitors), managerial and board compensation are closely aligned. Specifically, high pay-for-performance compensation is awarded to both managers and boards in firms with high-quality projects (i.e., $\theta = \theta_h$) and low-pay-for-performance compensation is awarded when the project quality is low (i.e., $\theta = \theta_l$).

The analysis also shows that when managers are able to engage in intense risk-seeking, the potential collusion of managers and boards affects the optimal board-manager compensation structure. Consistent with this insight, proposition 2.5.2 suggests that in firms with high managerial risk-seeking ability, the optimal compensation structure either strengthens the board's incentives to monitor managerial risk-seeking by awarding lower performance-based board compensation (i.e., the *disciplinary board case*) or reduces the manager's incentive to engage in risk-seeking activities by awarding lower managerial pay-for-performance compensation (i.e., the *contracting board case*). Furthermore, proposition 2.5.3 states the conditions in which the optimal compensation structure reduces managerial risk-seeking incentives by inducing the board to monitor managerial activities rather than by lowering managerial performance-based compensation. Specifically, when the board has lower monitoring costs (i.e., lower γ_b) or faces a larger variability in project quality (i.e., higher D_θ), the board's monitoring incentives can still be provided by low pay-for-performance board compensation.

From these insights, three empirical hypotheses can be derived concerning the structure of the managerial and board compensation. In particular, controlling for all other factors, firms are more likely to award their managers higher pay-for-performance compensation while simultaneously awarding their boards lower pay-for-performance compensation when: (i) managers can engage in risk-seeking activities more easily, (ii) boards can monitor managers at a lower cost and (iii) boards face a larger variability in project quality.

2.6 Empirical analysis

2.6.1 Data and sample construction

For the period 1996–2005 I collect information on CEO and board characteristics.[29] In particular, I gather information on CEO compensation, tenure and duality (i.e., whether or not the CEO also serves as the chairman of the board) from Execucomp. Regarding boards, I collect information about their compensation from Execucomp and about board structure (i.e., whether or not their directors are classified as independent) from RiskMetrics.[30] Following previous studies (e.g., Yermack 2004 and Ryan and Wiggins 2004) the empirical analysis exclusively considers outside directors' compensation which is consistent with the previously described implications and consistent with the fact that outside directors are in practice responsible for managerial monitoring.[31]

I obtain financial information and data on the number of business seg-

[29]From 2006 on Execucomp fails to provide information on board compensation.

[30]RiskMetrics classifies directors into three categories, namely, *insiders*, *linked directors* and *outsiders*. Following Ryan and Wiggins (2004) and Linck et al. (2008), I define an independent board as a board which has a majority of outside directors.

[31]For instance, the NYSE and NASDAQ exchanges require the listed firms to form audit committees (which are in charge of overseeing risk-management policies) and compensation committees (which are in charge of designing managerial compensation) entirely with outside directors.

ments from Compustat. After excluding utilities (SIC 4900–4999), the sample consists of 6496 non-financial firm years and 1003 financial firm years (SIC 6000–6999). Furthermore, as described below, for some of my tests I collect information on outside directors' blockholding ownership from the database provided by Dlugosz et al. (2006) which corrects the errors contained in Compact Disclosure during the period 1996–2001. The use of this corrected board ownership data makes it possible to investigate the effect of directors' blockholding ownership on CEO and directors compensation but this data requires a restricted sample period. To minimize this data limitation, in the following analysis I compare: (i) results from the extended sample period (1996–2005) without considering directors' blockholding ownership and (ii) results from the shorter sample period (1996–2001) including the corrected information on directors' blockholding ownership.[32] Variables are reported in real terms (i.e., adjusted for inflation using 2000 as a base year).

2.6.2 Determinants of compensation structure

2.6.2.1 Managerial risk-seeking ability

I use R&D expenditures as a proxy for managerial risk-seeking ability. Since R&D investments tend to generate uncertain future cash flows and create information asymmetry between managers and shareholders (e.g., Hall

[32] Among the firm-years that exist in Execucomp, RiskMetrics and Compustat during 1996–2001, 498 non-financial firm-years and 91 financial firm-years are not available in the blockholding ownership database. After excluding these firm-years, the shorter sample consists of 3323 firm-years of 925 non-financial firms and 509 firm-years of 144 financial firms.

and Lerner 2010), I postulate that R&D investments provide managers with opportunities to engage in risk-seeking activities. Specifically, for firm i and year t, I construct a dummy variable, $R\&D\_4yr_{i,t}$, which equals 1 for firm-years which have continuously recognized R&D expenses from $t-3$ to t and equals 0 otherwise.[33]

Since a key implication of my model is that managerial risk-seeking ability affects a firm's optimal compensation structure, I perform a second set of tests that compare the compensation practices of firms in the banking sector with firms outside banking.[34] These tests are built on the insight of previous studies (e.g., Laeven and Levine 2009) which suggest that in the banking sector it is hard to disentangle productive risky investments (e.g., profitable risky loans) from unproductive managerial risk-seeking activities (e.g., pure financial speculation). In other words since bank managers can easily engage in risk-seeking activities, the shareholders find it optimal to resort to a joint compensation structure in which managerial or board pay-for-performance compensation is reduced. In what follows, I define banking firms following the Fama-French 48 industry classification codes (i.e., the classification code equals 44).[35]

[33] In (unreported) robustness checks I consider a number of variations on the R&D expenditure proxy (i.e., different periods or R&D levels) and find similar results.

[34] While most studies on compensation exclude financial firms, I find it useful to include them in my empirical analysis in order to examine the effect of managerial risk-seeking abilities on the compensation structure. Nevertheless, to avoid potential distortions that arise from including financial firms, I present separate results for the sample of non-financial and financial firms below.

[35] In the Fama-French 48 classification code 44 includes some non-banking financial firms

2.6.2.2 Board monitoring costs

I postulate that the presence of at least one blockholder on the board is akin to a situation of low board-monitoring costs (and thus intense managerial monitoring). Specifically, since blockholding directors are exposed to financial losses in the case of bad firm performance, I expect that, as with low board-monitoring costs, the presence of blockholding directors leads to intense managerial monitoring even when no explicit pay-for-performance board compensation is used.

Following the literature (e.g., Dlugosz et al. 2006 and Villalonga and Amit 2006), I define blockholders as shareholders who own at least 5% of outstanding shares, and for firm i and year t, I construct a dummy variable $DIRBLK_{i,t}$ which equals 1 for firm-years which have at least one non-officer blockholder in the board and equals 0 otherwise.

2.6.2.3 Variability in the quality of projects

I consider two proxies for variability in project quality: the number of business segments and the firm's size. In the model, a larger variability in project quality refers to the case in which the board faces a higher *ex-ante* uncertainty relative to the optimal level of managerial pay-for-performance compensation. The link between larger variability in project quality and multi-segment (or larger) firms follows since these firms tend to operate in complex

(in SIC 6199) and code 47 includes a few investment banks (in SIC 6211). Excluding these firms, however, does not significantly affect the results.

business environments which make board monitoring particularly useful in the design of adequate managerial compensation.[36] Empirically the proxies considered in this analysis are $Segments_{i,t}$ and $ln(sale)_{i,t}$ which correspond to the number of segments and the natural log of sales for firm i and year t, respectively.[37]

2.6.2.4 Control variables

As controls I include a number of determinants of pay-for-performance compensation proposed by previous studies (e.g., Yermack 1995, Guay 1999a and Coles et al. 2006). First I consider the effect of a firm's past performance (i.e., past return on firm assets and past stock returns).[38] Specifically, I include lagged return on assets and annual stock returns (i.e., $ROA_{i,t-1}$ and $Return_{i,t-1}$ for firm i and year t).[39] Second, I include the KZ index modified by Baker et al. (2003), the market-to-book value ratio, and the presence of long-term debt indicator (i.e., $KZ4_{i,t}$, $MB_{i,t}$ and $LTD_{i,t}$, respectively) as proxies for the level of a firm's financial constraints.[40] Yermack (1995) reports that to defer

[36]In line with this insight, Fama and Jensen (1983) proposes board monitoring as a key governance mechanism for firms that operate in highly complex environments.

[37]Relative to other studies (e.g., Core and Guay 2001) which have considered the relationship between the firm size and the compensation structure, my model analysis predicts that the firm size has contrasting effects on CEO and directors compensation structures.

[38]Previous studies suggest contrasting predictions relative to the effect of the past performance on the level of pay-for-performance compensation. See, e.g., Core and Guay (2001) for the details.

[39]I consider both one-year and two-year lagged annual stock returns but excluding two-year lagged stock returns does not change the results.

[40]In unreported robustness checks I also consider cash flow shortfalls (i.e., [common and preferred dividends+cash flow used in investing activities-cash flow from operations]/total assets) which is also widely used as a proxy for the degree of financial constraints (e.g.,

the cash payout financially constrained firms tend to award managers stock options (which, as described below, I use as a measure for pay-for-performance compensation) in lieu of cash compensation.

Third, I control for tax effects on compensation by including an operating loss dummy variable $Loss_{i,t}$. Intuitively, firms that have net operating loss carryforwards expect higher future tax returns and thus desire to defer the compensation expense by awarding stock options. Fourth, I control for a firm's past stock return volatilities, namely $Vol_{i,t}$, since, as suggested by Kumar and Sivaramakrishnan (2008), firms that have experienced high stock return volatilities may not be willing to grant high pay-for-performance compensation that provides additional risk-taking incentives.[41]

In addition, I consider CEO and board characteristics relative to the CEO's influence on the board in order to capture situations in which CEOs can influence boards to design CEO pay with cash compensation rather than pay-for-performance compensation (Chhaochharia and Grinstein 2009). To control for the effects of CEO-board relationship on compensation, I include the board independence indicator, the logarithm of the CEO's tenure and the CEO-chairman duality indicator (i.e., $IND_{i,t}$, $Ln(tenure)_{i,t}$ and $Dual_{i,t}$, respectively).[42] Finally, I consider a new CEO indicator $NCEO_{i,t}$ to control for

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Yermack 1995).

[41]In the analysis of the joint compensation structure for the CEO and directors, it is particularly important to control for the stock return volatilities which affect a firm's stock option valuation and thus may generate a mechanical relationship between CEO and directors pay-for-performance compensation measures.

[42]To mitigate the endogeneity of board indpendence, I also consider only the post-SOX

the possible effects related to changes in compensation practices for incoming CEOs.[43] The details of each variable are available in Table 2.1.

2.6.3 Pay-for-performance compensation measures

I use stock option grants as the pay-for-performance compensation measures and main dependent variables in the analysis (e.g., Yermack 1995, Guay 1999a and Coles et al. 2006). Specifically, for each firm i and year t, I calculate the option-to-total compensation ratio $CEO\_r_{i,t}$ (resp. $BRD\_r_{i,t}$) in order to measure the extent to which CEOs' (resp. directors') pay is linked to the firms' performance. In addition, I consider a dummy variable $CEO\_p_{i,t}$ (resp. $BRD\_p_{i,t}$) which indicates whether or not a stock option plan is awarded to the CEO (resp. directors). More formally,

$$CEO\_r_{i,t}\,(BRD\_r_{i,t}) \equiv \frac{\text{Fair value of option grants to CEO (directors)}}{\text{Total compensation to CEO (directors)}},$$

$$CEO\_p_{i,t}\left(BRD\_p_{i,t}\right) \equiv \begin{cases} 1 & \text{if stock options are awarded to CEO (directors)} \\ 0 & \text{otherwise.} \end{cases}$$

Furthermore I consider three measures of the joint compensation structure of the CEO and directors (i.e., the association between the magnitudes of CEO and director pay-for-performance compensation for each firm-year). Specifically, for firm i and year t, three categorical variables $CEOBRD\_r_{i,t}$,

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period (2002-2005) in which almost all firms have independent board structures and find consistent results.

[43]See Fee and Hadlock (2003) for evidence of these effects.

$CEOBRD\_p_{i,t}$ and $CEOBRD\_indr_{i,t}$ classify firm-years into the following four categories:

(1) *LL*: firm-years in which both the CEO and directors are awarded low pay-for-performance compensation

(2) *LH*: firm-years in which the CEO is awarded low pay-for-performance and directors are awarded high pay-for-performance

(3) *HL*: firm-years in which the CEO is awarded high pay-for-performance and directors are awarded low pay-for-performance

(4) *HH*: firm-years in which both the CEO and directors are awarded high pay-for-performance compensation.

More specifically, $CEOBRD\_r_{i,t}$ classifies firm-years by comparing their option-to-total compensation ratios (i.e., $\mathrm{CEO\_r_{i,t}}$ and $\mathrm{BRD\_r_{i,t}}$) with the corresponding median for each year. In addition, to control for industry characteristics, $CEOBRD\_indr_{i,t}$ classifies firm-years by comparing the option-to-total compensation ratios with the corresponding industry-year medians. Finally, $CEOBRD\_p_{i,t}$ classifies firm-years by the presence of option award plans for the CEO and directors.[44]

[44] A formal definition of each variable is available in Table 2.1.

2.6.4 Descriptive statistics

Table 2.2 presents summary statistics of CEO and board compensation in non-financial firms (Panel A) and financial firms (Panel B). In non-financial firms the average directors compensation is \$0.21 million and the average CEO compensation is \$5.46 million. While CEO pay is substantially larger than director pay, both CEOs and directors receive stock options as the main form of equity-based compensation. In particular, directors (resp. CEOs) receive stock options in approximately 72% (resp. 80%) of firm-years and on average the value of options granted accounts for 45% (resp. 39%) of total pay for directors (resp. CEOs).[45] Panel A also shows that R&D firms (i.e., $R\&D\_4yr_{i,t} = 1$) grant stock options more intensively to both CEOs and directors. On average the value of options granted accounts for nearly 49% (resp. 43%) of directors (resp. CEO) pay in R&D firms relative to 40% (resp. 34%) in other firms.

A comparison between Panel A (non-financial firms) and Panel B (financial firms) shows that the level of directors pay is similar in both types of firms but CEO pay is much higher in financial firms. In addition financial firms award directors fewer stock options than non-financial firms. Within the sample outside directors receive stock options in only 60% of financial firm-years and on average the value of options granted accounts for 36% of the total directors pay. Among financial firms, banks grant even fewer option awards to outside directors. Banks grant stock options in only 54% of firm-years and

[45] These results are in line with previous studies about directors compensation (e.g., Ryan and Wiggins 2004 and Yermack 2004).

the value of options granted constitutes only 31% of directors' total pay.

Table 2.3 describes the measures of the joint compensation structure in non-financial firms (Panel A) and financial firms (Panel B). Panel A shows that in non-financial firms the magnitudes of CEO and director pay-for-performance compensation are positively correlated. In 60% of non-financial firm-years both the CEO's and directors' option-to-total compensation ratios are simultaneously below or above the corresponding industry-year medians (i.e., $CEO\text{-}BRD\_indr_{i,t} = LL$ or HH). Panel A also indicates that R&D firms are more likely to award high pay-for-performance compensation either simultaneously to both the CEO and directors or to the CEO alone. In particular, R&D firms exhibit a 5% (resp. 2%) higher probability that both the CEO's and directors' (resp. only the CEO's) option-to-total compensation ratios are above the industry-year median.

A comparison between Panel A (non-financial firms) and Panel B (financial firms) shows that financial firms tend to grant high pay-for-performance to the CEO and low pay-for-performance to directors rather than simultaneously awarding high pay-for-performance to both. Specifically, financial firms (resp. non-financial firms) award stock options only to the CEO (i.e., $CEO\text{-}BRD\_p_{i,t} = HL$) in 31% (resp. 21%) of firm-years. Among financial firms, banks are more likely to award high pay-for-performance to the CEO and low pay-for-performance to directors. In particular, banks award stock options to the CEO alone in 38% of firm-years.

Table 2.4 summarizes the proxies for determinants of the compensation structure in non-financial firms (Panel A) and financial firms (Panel B). Panel A shows that R&D firms are less likely to have non-officer blockholding directors and tend to have more business segments and smaller firm size. Specifically, R&D firms have at least one non-officer blockholding director in 6% of firm-years while other firms have such a director in 11% of firm years. R&D firms also show more operating loss, more growth opportunities and higher stock return volatilities. Regarding the measures of the board-manager relationship, R&D firms are more likely to have independent boards. In 80% of firm-years, R&D firms maintain the board with a majority of independent directors while other firms do so in only 69% of firm-years..

Relative to non-financial firms (Panel A), financial firms (Panel B) tend to have a larger firm size, more reliance on long-run debt and fewer growth opportunities. In terms of the board-manager relationship, financial firms are more likely to have the CEO-Chair duality and independent boards. In addition Panel B shows that banks are more financially constrained and have fewer growth opportunities than other financial firms. Banks are also more likely to have independent boards. In 88% of firm-years banks maintain their boards with a majority of outside directors.

2.7 Results

2.7.1 CEO and directors pay-for-performance compensation

I start by individually estimating the regressions of CEO and directors compensation on the determinants of compensation structure (i.e., managerial risk-seeking abilities, board monitoring costs and the variability in project quality).[46] According to the model CEO and directors compensation structures are jointly determined and thus running each regression of CEO and directors compensation potentially suffers from simultaneity bias. However, the estimates from each regression provide descriptive information about the effects of the determinants of compensation structures and also can be compared to previous studies which examine CEO and directors compensation independently.[47]

2.7.1.1 Non-financial firms

Table 2.5 presents the regression results for non-financial firms. Specifically, the regressions reported in columns 1–4 differ in their sample periods and dependent variables. More specifically, columns 1 and 2 present the results from the extended sample period (i.e., 1996–2005 without directors' blockholding ownership) and columns 3 and 4 report the results from the shorter sample (i.e., 1996–2001 including directors' blockholding ownership). Furthermore, the dependent variables are (CEO_p and BRD_p) in columns 1 and 3 while (CEO_r and BRD_r) in 2 and 4.

The results show that lower magnitudes of pay-for-performance compensation tend to be awarded to directors in R&D firms, in firms with at least

[46] To adjust the standard errors for the correlation between managerial and board pay-for-performance measures in each firm-year, I use the seemingly unrelated regression (SUR).

[47] See, e.g., Yermack 1995, Guay 1999a and Coles et al. 2006 for research on CEO compensation and Yermack (2004) and Ryan and Wiggins (2004) for studies on directors compensation.

one non-officer blockholding director, in more diversified firms and in larger firms. Specifically, column 3 reports that, all else being equal, the probability of awarding stock option grants to directors are about 5% (resp. 6.2%) lower in R&D firms (resp. firms that have non-officer blockholders in the board). Furthermore, each additional segment (resp. 1% increase in sales) is associated with 1.5% (resp. 2.9%) lower odds of awarding options to directors. These results suggest that, as predicted by the model analysis, lower magnitudes of pay-for-performance compensation for directors are associated with higher managerial risk-seeking ability, lower board monitoring costs and larger variability in (potential) project quality.

Table 2.5 also shows that R&D firms, more diversified firms and larger firms tend to award higher pay-for-performance compensation to the CEO while firms with at least one non-officer blockholding director tend to grant lower pay-for-performance compensation to the CEO. In particular, column 4 shows that, all else being equal, the CEO's option-to-total compensation ratio is around 4.8% higher in R&D firms and 3.7% lower in firms which have at least one non-officer blockholding director. Column 4 also reports that a 1% increase in sales is associated with a 3.1% higher option-to-total compensation ratio. The effect of the number of segments on this ratio is positive but statistically insignificant.[48] These results imply that higher managerial risk-seeking ability and larger variability in project quality are associated with higher pay-for-

[48]As shown in column 3 of Table 2.5, the positive relationship between the number of segments and the odds of awarding the CEO stock option grants is statistically significant.

performance compensation for CEOs.

2.7.1.2 Financial firms

Table 2.6 reports the results for financial firms. As in Table 2.5, columns 1 and 2 present the results from the extended sample period (1996–2005 without directors' blockholding ownership) and by contrast columns 3 and 4 report the results from the shorter sample (i.e., 1996–2001 including directors' blockholding ownership). The dependent variables are (CEO_p and BRD_p) in the regressions reported in columns 1 and 3 and (CEO_r and BRD_r) in columns 2 and 4. To compare the compensation structure of banks with other financial firms I include the bank indicator and exclude the industry-fixed effects.[49]

Table 2.6 shows that banking firms award lower pay-for-performance compensation to outside directors. In particular, column 3 reports that banks show a nearly 16% lower probability of awarding stock options to directors. Consistent with the results from non-financial firms, firms with non-officer blockholding directors or that have larger sales tend to award lower pay-for-performance compensation to directors. Column 3 shows that the firms with at least one non-officer blockholding director have a 21.3% lower probability of awarding stock options to directors and a 1% increase in sales lowers this probability by 5.4%.

[49] I also exclude $R\&D\_4yr_{i,t-1}$ and $Segments_{i,t-1}$ which have very small variation within financial firms but considering the two variables does not substantially change the coefficient estimates of other variables.

In contrast, banks and other firms do not exhibit a significant difference in the level of pay-for-performance compensation for CEOs. Furthermore, the relationship between the presence of non-officer blockholding directors and the magnitude of CEO pay-for-performance compensation is also statistically insignificant. In line with the result from non-financial firms, however, larger firms tend to award higher pay-for-performance compensation to the CEO. Overall, the findings suggest that banks in which CEOs can easily engage in risk-seeking activities tend to grant lower pay-for-performance compensation to directors.

2.7.2 CEO-directors joint compensation structure

I now consider the determinants of the joint compensation structure and more specifically the determinants of the association between the magnitudes of the CEO's and the directors' pay-for-performance compensation. To do so I estimate a multinomial logit model with *CEOBRD_r*, *CEOBRD_p* and *CEOBRD_indr* as dependent variables. As before, I consider separate models for non-financial and financial firms.

2.7.2.1 Non-financial firms

Table 2.7 presents the results for non-financial firms. Rather than reporting coefficient estimates, Table 2.7 reports average partial effects which better illustrate the economic magnitude as well as the statistical significance.[50] Panel A reports the results from the extended sample period (i.e., 1996–2005 without directors' blockholding ownership) and Panel B reports the results from the shorter sample period (i.e., 1996–2001 including directors' blockholding ownership, $DIRBLK_{i,t}$). Standard errors are adjusted for clusters within an industry and include all control variables considered in Table 2.5.

Panel B shows three main results. First, R&D firms are more likely to offer high pay-for-performance compensation to CEOs and low pay-for-performance compensation to directors. In Panel B, R&D firms show 7.3% higher odds that the CEO's (resp. directors') option-to-total compensation ratio is above (resp. below) the industry-year median (i.e., *CEOBRD_indr=HL*). Consistent with these findings, R&D firms show a 6.6% higher probability of awarding options only to the CEO (i.e., *CEOBRD_p=HL*).

Second, Panel B shows that firms which have non-officer blockholding directors are less likely to award high pay-for-performance compensation to the CEO and to the directors simultaneously. Instead, these firms award high pay-for-performance to the CEO and low pay-for-performance to directors. Specifically, these firms show a nearly 8% higher probability that the CEO's (resp. directors') option-to-total compensation ratio is above (resp. below) year median (i.e., *CEOBRD_r=HL*) and a 12.2% lower probability that both the CEO's and the directors' option-to-total compensation ratios are above the

[50] Partial effects of control variables are unreported but available from the author upon request.

year medians (i.e., *CEOBRD_r=HH*). Consistently, the probability of awarding options to CEOs and directors simultaneously (i.e., *CEOBRD_p=HH*) are 7.5 % lower in these firms.

Finally, Panel B also reports that larger or more diversified firms also tend to award higher pay-for-performance CEO compensation and lower pay-for-performance director compensation. Specifically each additional segment (resp. 1% increase in sales) is associated with 1.8% (resp. 3.2%) higher odds that both the CEOs' and the directors' option-to-total compensation ratios are simultaneously above the industry-medians (i.e., *CEOBRD_indr=HL*).

In general, these findings are in line with my model analysis which predicts that the *disciplinary board case* is more likely to occur in firms in which (i) managerial risk-seeking activities are more likely to occur (ii) board monitoring costs are likely to be lower and (iii) projects can exhibit a large variability in quality. In the *disciplinary board case*, consistent with the reported evidence, directors are awarded low pay-for-performance compensation while CEOs receive simultaneous high pay-for-performance compensation.

2.7.2.2 Financial firms

Table 2.8 reports the results for financial firms which, as shown in Section 2.7.1.2, compare the effects on banks with other financial firms.[51] Panels A and B report the results from the extended sample period (i.e., 1996–2005

[51] As before, I exclude $R\&D\_4yr_{i,t-1}$ and $Segments_{i,t-1}$ from independent variables.

without directors' blockholding ownership) and from the shorter sample period (i.e., 1996–2001 including directors' blockholding ownership), respectively. Standard errors are adjusted for clusters within an industry only in Panel A but are unadjusted in Panel B because of the insufficient number of observations.

Relative to other financial firms, banks show a 17% higher probability of awarding stock options to the CEO alone (i.e., *CEOBRD_p=HL*) and a 14.1% lower probability of awarding options to the CEO and directors simultaneously (i.e., *CEOBRD_p=HH*). However, this difference between banks and other firms is not significantly observed in other joint compensation measures.[52]

In line with the results from non-financial firms, larger firms and firms with non-officer blockholding directors are less likely to award high pay-for-performance compensation to both the CEO and the directors but rather they award high pay-for-performance compensation to the CEO and low pay-for-performance compensation to directors simultaneously. Specifically, the presence of non-officer blockholding directors (resp. 1% increase in sales) is associated with 21.3% (resp. 5.1%) higher odds of awarding stock options to the CEO alone and 21.8% (resp. 4.2%) lower odds of awarding options to the CEO and directors simultaneously. Overall, these results confirm previous findings that higher managerial risk-seeking ability, lower board monitoring costs and larger variability in project quality lead to the simultaneous award of

[52]Banks show higher odds that *CEOBRD_indr=HH* but, as displayed in Table 2.3, the median of directors' option-to-total compensation ratio in the banking sector is fairly low.

high pay-for-performance compensation to CEOs and low pay-for-performance compensation to directors.

2.8 Concluding remarks

This paper considers the optimal managerial and board compensation in a setting in which both managers and boards are subject to agency problems and shareholders delegate to boards the task of designing managerial compensation and the task of monitoring managerial risk-seeking activities. The model shows that while high pay-for-performance board compensation provides incentives for the board to properly design managerial compensation, it also diminishes the board's incentive to discourage non-productive managerial risk-shifting activities. This analysis implies that the optimal board compensation structure is determined by the trade-off between the magnitudes of these two countervailing effects. The analysis also derives implications for the optimal joint compensation structure for managers and boards.

The analysis suggests that the three determinants that shape the optimal compensation structure for managers and boards are (i) managerial risk-seeking ability, (ii) the magnitude of board monitoring costs and (iii) the variability in (potential) project quality. The analysis predicts that, all else being equal, high pay-for-performance compensation for managers and low pay-for-performance compensation for boards are awarded by firms in which the managerial risk-seeking ability is higher, the board monitoring costs are lower and the projects exhibit lower variability in quality.

In the second part of the study I take these predictions into the data. Empirically, I find that high managerial pay-for-performance compensation tends to be awarded jointly with low board pay-for-performance in (i) R&D firms or banks in which managers can easily engage in risk-seeking activities (ii) firms in which the board contains non-officer blockholders who are likely to provide high-intensity monitoring and (iii) larger or more diversified firms which feature a wider variability in project quality.

The analysis of the joint compensation structure for managers and boards provides some novel findings and suggests several avenues for future research. However, the study abstracts from issues related to the dynamics of board composition and other governance mechanisms which can affect the relationship between CEO and board compensation. Fascinating but challenging tasks to include board dynamics and to examine the joint compensation structure in the presence of a richer set of governance mechanisms are left for future research.

Table 2.1: Definition of variables

Variable	Definition
CEO(BRD)_total$_{i,t}$	Total compensation to the CEO (outside director) in firm i and year t
CEO(BRD)_option$_{i,t}$	Black-Scholes value of option grants to the CEO (outside director)
CEO(BRD)_p$_{i,t}$	Indicator (1,0) of option grants to the CEO (outside director)
CEO(BRD)_r$_{i,t}$	CEO_option$_{i,t}$/CEO_total$_{i,t}$ (BRD_option$_{i,t}$/BRD_total$_{i,t}$)
CEO(BRD)_stk$_{i,t}$	Dollar amount of stock grants to the CEO (outside director)
CEO(BRD)_stkp$_{i,t}$	Indicator (1,0) of stock grants to the CEO (outside director)
CEO(BRD)_stkr$_{i,t}$	CEO_stk/CEO_total (BRD_stk/BRD_total)
ROA$_{i,t}$	Return on Asset reported in Execucomp
Loss$_{i,t}$	Net operating loss dummy (=1 if oibdp$_{i,t}$ ¡ 0)
LTD$_{i,t}$	long term debt dummy (=1 if dltt$_{i,t}$¿0)
kz4$_{i,t}$	-1.002*kz_cf$_{i,t}$-39.368*kz_div$_{i,t}$-1.315*kz_c$_{i,t}$+3.139*kz_lev$_{i,t}$
kz_cf$_{i,t}$	(dp$_{i,t}$+ib$_{i,t}$)/at$_{i,t}$
kz_div$_{i,t}$	(dvp$_{i,t}$+dvc$_{i,t}$)/at$_{i,t}$
kz_c$_{i,t}$	che/at$_{i,t}$
kz_lev$_{i,t}$	(dltt$_{i,t}$+dlc$_{i,t}$)/(dltt$_{i,t}$+dlc$_{i,t}$+seq$_{i,t}$)
Return	1-year stock return
MB	(prcc_f$_{i,t}$*csho$_{i,t}$+at$_{i,t}$-ceq$_{i,t}$-txdb$_{i,t}$)/at$_{i,t}$
R&D	3-year moving average of (xrd$_{i,t}$/at$_{i,t}$)
Vol	Stock return volatility reported in Execucomp
IND	Board independence dummy (=1 if the board holds a majority of independent directors)
Tenure	the CEO's tenure
NCEO	New CEO dummy (=1 for the first year of the CEO)
Dual	CEO-Chair dummy (=1 if the CEO is the chairman of the board)
CEO_m$_t$ (BRD_$_{-t}$)	the year-median of CEO_r$_{i,t}$ (BRD_r$_{i,t}$)
CEO_indm$_t$ (BRD_indm$_t$)	the Fama-French 48 industry-year median of CEO_r$_{i,t}$ (BRD_r$_{i,t}$)
CEOBRD_r$_{i,t}$	$\begin{cases} LL & \text{if } CEO\_r_{i,t} \leq CEO\_m_t \text{ and } BRD\_r_{i,t} \leq BRD\_m_t \\ LH & \text{if } CEO\_r_{i,t} \leq CEO\_m_t \text{ and } BRD\_r_{i,t} > BRD\_m_t \\ HL & \text{if } CEO\_r_{i,t} > CEO\_m_t \text{ and } BRD\_r_{i,t} \leq BRD\_m_t \\ HH & \text{otherwise.} \end{cases}$
CEOBRD_p$_{i,t}$	$\begin{cases} \mathrm{LL} & \text{if } \mathrm{CEO\_p_{i,t}} = \mathrm{BRD\_p_{i,t}} = 0 \\ \mathrm{LH} & \text{if } \mathrm{CEO\_p_{i,t}} = 0 \text{ and } \mathrm{BRD\_p_{i,t}} = 1 \\ \mathrm{HL} & \text{if } \mathrm{CEO\_p_{i,t}} = 1 \text{ and } \mathrm{BRD\_p_{i,t}} = 0 \\ \mathrm{HH} & \text{otherwise,} \end{cases}$
CEOBRD_indr$_{i,t}$	$\begin{cases} \mathrm{LL} & \text{if } \mathrm{CEO\_r_{i,t}} \leq \mathrm{CEO\_indm_t} \text{ and } \mathrm{BRD\_r_{i,t}} \leq \mathrm{BRD\_indm_t} \\ \mathrm{LH} & \text{if } \mathrm{CEO\_r_{i,t}} \leq \mathrm{CEO\_indm_t} \text{ and } \mathrm{BRD\_r_{i,t}} > \mathrm{BRD\_indm_t} \\ \mathrm{HL} & \text{if } \mathrm{CEO\_r_{i,t}} > \mathrm{CEO\_indm_t} \text{ and } \mathrm{BRD\_r_{i,t}} \leq \mathrm{BRD\_indm_t} \\ \mathrm{HH} & \text{otherwise,} \end{cases}$

This table presents the definition of compensation variables and control variables. For the fair value of equity grants to managers, I use the corresponding measures provided by Execucomp. To value the equity grants to outside directors, I follow Ryan and Wiggins (2004). For financial and accounting variables, I describe the definition by using the compustat data items. The independent directors are identified by teh classification of Riskmetrics database. For each firm year, I identify the chairperson from Riskmetrics database while find the CEO from Execucomp. In particualr, the appointment and resignation date of CEOs are provided by Execucomp.

Table 2.2: Summary statistics: Compensation

Panel A: Non-financial firms

	All firms			R&D firms			Other firms			Diff.	
	mean	sd	median	mean	sd	median	mean	sd	median	mean	t
CEO_total	5459.28	13924.72	2817.74	5907.44	17190.07	3082.68	4966.35	9040.80	2550.79	941.09	2.99
CEO_option	2900.99	10232.15	962.32	3353.52	12244.21	1219.14	2403.26	7383.16	691.56	950.26	4.10
CEO_p	0.80	0.40	1	0.84	0.37	1	0.76	0.42	1	0.07	7.91
CEO_r	0.39	0.29	0.38	0.43	0.29	0.44	0.34	0.27	0.32	0.09	14.43
CEO_stk	621.75	8260.83	0	637.58	11226.93	0	604.33	2163.79	0	33.25	0.18
CEO_stkp	0.27	0.44	0	0.24	0.43	0	0.31	0.46	0	-0.06	-6.21
CEO_stkr	0.07	0.15	0	0.06	0.14	0	0.08	0.15	0	-0.02	-5.55
BRD_total	206.66	574.38	96.75	267.87	740.97	108.77	139.34	283.43	83.84	128.53	10.05
BRD_option	155.11	575.87	36.84	214.42	743.76	45.32	89.87	282.69	27.37	124.55	9.71
BRD_p	0.72	0.45	1	0.74	0.44	1	0.69	0.46	1	0.05	4.87
BRD_r	0.45	0.36	0.47	0.49	0.37	0.53	0.40	0.34	0.40	0.08	10.12
BRD_stk	19.68	51.94	0	21.44	60.21	0	17.75	40.89	0	3.68	3.11
BRD_stkp	0.40	0.49	0	0.41	0.49	0	0.40	0.49	0	0.01	0.95
BRD_stkr	0.16	0.24	0	0.16	0.24	0	0.16	0.24	0	0.00	0.60
Obs.		7442			3898			3544			

Panel B: Financial firms

	All firms			Banks			Other firms			Diff.	
	mean	sd	median	mean	sd	median	mean	sd	median	mean	t
CEO_total	7428.81	11135.43	4035.32	7314.28	13436.57	3385.14	7552.12	7958.75	4878.86	-237.84	-0.34
CEO_option	3360.48	8535.52	1302.05	3541.59	10935.49	1116.86	3165.49	4755.60	1622.97	376.11	0.71
CEO_p	0.83	0.37	1	0.86	0.35	1	0.80	0.40	1	0.06	2.46
CEO_r	0.36	0.26	0.34	0.35	0.25	0.33	0.36	0.27	0.36	-0.01	-0.31
CEO_stk	1014.61	2826.64	0	948.14	2847.14	0	1086.17	2805.59	0	-138.04	-0.77
CEO_stkp	0.39	0.49	0	0.39	0.49	0	0.38	0.49	0	0.01	0.31
CEO_stkr	0.10	0.17	0	0.10	0.16	0	0.11	0.17	0	-0.01	-0.73
BRD_total	223.56	2248.00	91.08	111.02	177.88	64.81	344.72	3231.56	125.10	-233.70	-1.59
BRD_option	158.84	2247.40	21.96	57.08	171.02	10.75	268.39	3231.89	46.05	-211.31	-1.44
BRD_p	0.60	0.49	1	0.54	0.50	1	0.67	0.47	1	-0.13	-4.31
BRD_r	0.36	0.35	0.36	0.31	0.33	0.26	0.42	0.36	0.44	-0.12	-5.47
BRD_stk	32.32	85.12	0	21.81	61.57	0	43.63	103.61	0	-21.82	-4.02
BRD_stkp	0.43	0.49	0	0.38	0.49	0	0.48	0.50	0	-0.11	-3.39
BRD_stkr	0.20	0.28	0	0.16	0.25	0	0.24	0.30	0	-0.07	-4.18
Obs.		1003			520			483			

Table 2.2: Summary statistics: Compensation

(Continued from the previous page)

This table presents the summary statistics about compensation for CEO and outside directors between 1997 and 2005. The sample consists of 7442 non-financial firm years and 1003 financial firm years. The utilities (sic 4900–4999) are excluded from the sample. Compensation information is obtained from Execucomp database. Panel A reports the compensation of non-financial firms and also separately presents the compensation of R&D firms and other non-financial firms. Financial firms are defined as the firms whose standard industrical classsification is between 6000 and 6999. R&D firms are defined as the firms which recognize the R&D expenditure for the past four consecutive years. The last two columns in Panel A presents the mean difference between long R&D firms and other non-financial firms and the unpaired t-statistics (computed for unequal variance and unequal observations) which tests for the null hypothesis that the mean difference is zero. Panel B reports the compensation of financial firms and also separately presents the compensation of banks and non-bank financial firms. Banks are defined as the firms whose Fama-French 48 industrial classification code is 44. As in Panel A, the last two columns of Panel B presents the mean difference between banks and other financial firms and the corresponding t-statistics. The details about compensation variables are available in Table 2.1.

Table 2.3: Summary statistics: CEO-directors joint compensation structure

Panel A: Non-financial firms

	All firms			R&D firms			Other firms			Diff.	
	mean	sd	median	mean	sd	median	mean	sd	median	mean	t
CEOBRD_r=LL	0.27	0.45	0	0.22	0.42	0	0.33	0.47	0	-0.11	-10.27
CEOBRD_r=LH	0.17	0.38	0	0.16	0.37	0	0.19	0.39	0	-0.03	-3.13
CEOBRD_r=HL	0.22	0.42	0	0.23	0.42	0	0.21	0.41	0	0.02	2.20
CEOBRD_r=HH	0.33	0.47	0	0.39	0.49	0	0.27	0.45	0	0.11	10.38
CEOBRD_p=LL	0.07	0.26	0	0.05	0.22	0	0.10	0.30	0	-0.05	-8.46
CEOBRD_p=LH	0.12	0.33	0	0.11	0.32	0	0.14	0.34	0	-0.02	-2.80
CEOBRD_p=HL	0.21	0.41	0	0.21	0.41	0	0.21	0.41	0	0.00	0.08
CEOBRD_p=HH	0.59	0.49	1	0.63	0.48	1	0.56	0.50	1	0.07	6.36
CEOBRD_indr=LL	0.30	0.46	0	0.28	0.45	0	0.33	0.47	0	-0.05	-4.85
CEOBRD_indr=LH	0.17	0.38	0	0.16	0.37	0	0.19	0.39	0	-0.02	-2.37
CEOBRD_indr=HL	0.23	0.42	0	0.24	0.43	0	0.22	0.41	0	0.02	2.54
CEOBRD_indr=HH	0.29	0.45	0	0.31	0.46	0	0.27	0.44	0	0.05	4.56
Obs.	7442			3898			3544				

Panel B: Financial firms

	All firms			Banks			Other firms			Diff.	
	mean	sd	median	mean	sd	median	mean	sd	median	mean	t
CEOBRD_r=LL	0.29	0.45	0	0.34	0.48	0	0.23	0.42	0	0.11	3.88
CEOBRD_r=LH	0.17	0.38	0	0.14	0.34	0	0.21	0.41	0	-0.07	-3.04
CEOBRD_r=HL	0.30	0.46	0	0.32	0.47	0	0.27	0.44	0	0.05	1.88
CEOBRD_r=HH	0.24	0.43	0	0.20	0.40	0	0.29	0.45	0	-0.09	-3.39
CEOBRD_p=LL	0.09	0.28	0	0.08	0.27	0	0.10	0.30	0	-0.02	-1.14
CEOBRD_p=LH	0.08	0.27	0	0.06	0.24	0	0.10	0.30	0	-0.04	-2.20
CEOBRD_p=HL	0.31	0.46	0	0.38	0.49	0	0.23	0.42	0	0.15	5.32
CEOBRD_p=HH	0.52	0.50	1	0.48	0.50	0	0.57	0.50	1	-0.09	-3.00
CEOBRD_indr=LL	0.24	0.43	0	0.26	0.44	0	0.23	0.42	0	0.03	1.18
CEOBRD_indr=LH	0.21	0.40	0	0.20	0.40	0	0.22	0.41	0	-0.02	-0.67
CEOBRD_indr=HL	0.24	0.43	0	0.25	0.43	0	0.23	0.42	0	0.02	0.83
CEOBRD_indr=HH	0.31	0.46	0	0.29	0.46	0	0.33	0.47	0	-0.04	-1.26
Obs.	1003			520			483				

Table 2.3: Summary statistics: CEO-directors joint compensation structure

(Continued from the previous page)

This table presents the summary statistics about categorical variables constrctured by compensation for CEO and outside directors. The details about categorical compensation variables are available in Table 2.1. The sample consists of 7442 non-financial firm years and 1003 financial firm years between 1997 and 2002. Compensation information is obtained from Execucomp database. Panel A reports the summary statistics about categorical variables of non-financial firms and also separately presents the summary statistics of R&D firms and other non-financial firms. Financial firms are defined as the firms whose standard industrical classsification is between 6000 and 6999. R&D firms are defined as the firms which recognize the R&D expenditure for the past four consecutive years. The last two columns in Panel A presents the mean difference between long R&D firms and other non-financial firms and the corresponding t-statistics (computed for unequal variance and unequal observations) of the null hypothesis that the mean difference is zero. Panel B reports the compensation of financial firms and also separately presents the compensation of banks and non-bank financial firms. Banks are defined as the firms whose Fama-French 48 industrial classification code is 44. As in Panel A, the last two columns of Panel B presents the mean difference between banks and other financial firms and the corresponding t-statistics.

Table 2.4: Summary statistics: Independent variables

Panel A: Non-financial firms

	All firms				R&D firms				Other firms				Diff.	
	mean	sd	median	Obs.	mean	sd	median	Obs.	mean	sd	median	Obs.	mean	t
DIRBLK	0.08	0.27	0	3731	0.06	0.23	0	2002	0.11	0.31	0	1729	-0.05	-5.86
Segments	1.72	1.04	1	6496	1.83	1.13	1	3494	1.60	0.90	1	3002	0.22	8.89
ln(sale)	7.40	1.50	7.29	7442	7.26	1.62	7.16	3898	7.54	1.36	7.41	3544	-0.28	-8.20
ROA	0.04	0.14	0.05	7442	0.03	0.17	0.05	3898	0.05	0.08	0.05	3544	-0.02	-7.09
Loss	0.04	0.20	0	7442	0.06	0.25	0	3898	0.01	0.12	0	3544	0.05	11.20
KZ4	0.22	1.17	0.28	7442	0.05	1.14	0.04	3898	0.41	1.17	0.53	3544	-0.37	-13.69
LTD	0.87	0.34	1	7442	0.84	0.37	1	3898	0.90	0.29	1	3544	-0.06	-8.42
Return	0.04	0.46	0.08	7442	0.03	0.49	0.08	3898	0.06	0.43	0.09	3544	-0.03	-2.52
MB	2.17	1.61	1.66	7442	2.43	1.86	1.83	3898	1.88	1.22	1.51	3544	0.56	15.41
R&D	0.03	0.06	0.01	7442	0.06	0.07	0.04	3898	0.00	0.01	0.00	3544	0.06	58.74
Vol	0.44	0.19	0.39	7442	0.47	0.21	0.41	3898	0.41	0.16	0.38	3544	0.06	12.42
Ln(tenure)	1.77	0.87	1.79	7442	1.71	0.87	1.61	3898	1.82	0.87	1.79	3544	-0.11	-5.44
NCEO	0.08	0.27	0	7442	0.09	0.28	0	3898	0.08	0.27	0	3544	0.01	1.73
Dual	0.66	0.47	1	7442	0.67	0.47	1	3898	0.65	0.48	1	3544	0.02	1.64
IND	0.75	0.43	1	7442	0.80	0.40	1	3898	0.69	0.46	1	3544	0.12	11.66

Panel B: Financial firms

	All firms				Banks				Other firms				Diff.	
	mean	sd	median	Obs.	mean	sd	median	Obs.	mean	sd	median	Obs.	mean	t
DIRBLK	0.08	0.27	0	509	0.09	0.29	0	278	0.06	0.23	0	231	0.04	1.61
ln(sale)	7.84	1.52	7.66	1003	7.72	1.56	7.52	520	7.98	1.46	7.79	483	-0.26	-2.76
ROA	0.03	0.05	0.01	1003	0.01	0.01	0.01	520	0.04	0.07	0.03	483	-0.03	-8.86
Loss	0.01	0.12	0	1003	0.00	0.00	0	520	0.03	0.17	0	483	-0.03	-3.93
KZ4	1.08	1.14	1.28	1003	1.80	0.64	1.91	520	0.31	1.06	0.38	483	1.48	26.63
LTD	0.93	0.26	1	1003	0.97	0.16	1	520	0.88	0.32	1	483	0.09	5.58
Return	0.10	0.36	0.12	1003	0.10	0.36	0.11	520	0.11	0.37	0.14	483	-0.02	-0.82
MB	1.45	1.08	1.13	1003	1.18	0.50	1.11	520	1.73	1.41	1.19	483	-0.55	-8.20
R&D	0.00	0.02	0.00	1003	0.00	0.00	0.00	520	0.00	0.02	0.00	483	0.00	-4.08
Vol	0.34	0.14	0.30	1003	0.30	0.12	0.28	502	0.37	0.15	0.34	483	-0.07	-7.94
Ln(tenure)	1.81	0.88	1.95	1003	1.84	0.85	1.95	520	1.77	0.90	1.79	483	0.07	1.19
NCEO	0.07	0.26	0	1003	0.07	0.25	0	520	0.08	0.27	0	483	-0.02	-0.93
Dual	0.70	0.46	1	1003	0.75	0.43	1	520	0.65	0.48	1	483	0.10	3.46
IND	0.79	0.41	1	1003	0.88	0.33	1	520	0.70	0.46	1	483	0.18	7.03

Table 2.4: Summary statistics: Independent variables

(Continued from the previous page)

This table presents the summary statistics about the firm characteristics of the sample, which consists of 7442 non-financial firm years and 1003 financial firm years between 1996 and 2004. Among them, 6496 non-financial firm years are available in segments database while 3731 non-financial and 509 financial firm years are available in blockholding ownership database which covers between 1996 and 2001. The utilities (sic 4900–4999) are excluded from the sample. I obtain financial and accounting information from Compustat database, board structure from Riskmetrics database, blockholding ownership from the data provided by Dlugosz et al. (2006), and business segment information from the Compustat segment database. Panel A reports the characteristics of non-financial firms and also separately presents the characteristics of R&D firms and other non-financial firms. Financial firms are defined as the firms whose standard industrical classsification is between 6000 and 6999. R&D firms are defined as the firms which recognize the R&D expenditure for the past four consecutive years. The last two columns in Panel A presents the mean difference between R&D firms and other firms and the unpaired t-statistics (computed for unequal variance and unequal observations) which tests for the null hypothesis that the mean difference is zero. Panel B reports the characteristics of financial firms and also separately presents the characteristics of banks and non-bank financial firms. Banks are defined as the firms whose Fama-French 48 industrial classification code is 44. As in Panel A, the last two columns of Panel B presents the mean difference between banks and other financial firms and the corresponding t-statistics. The details about all variables are available in Table 2.1.

Table 2.5: CEO and directors pay-for-performance compensation and determinants of compensation structure: Non-financial firms

	(1)		(2)		(3)		(4)	
	CEO_p	BRD_p	CEO_r	BRD_r	CEO_p	BRD_p	CEO_r	BRD_r
R&D_4yr (t-1)	0.0511***	-0.0312**	0.0477***	0.0179	0.0282	-0.0501**	0.0478***	0.0194
	(3.52)	(-1.98)	(4.85)	(1.60)	(1.51)	(-2.32)	(3.54)	(1.29)
DIRBLK					-0.0298	-0.0617**	-0.0372**	-0.0363*
					(-1.29)	(-2.30)	(-2.23)	(-1.96)
Segments	-0.00814	-0.0173***	-0.0108***	-0.0245***	0.0136**	-0.0152*	0.00548	-0.0174***
	(-1.49)	(-2.93)	(-2.92)	(-5.81)	(1.98)	(-1.91)	(1.10)	(-3.14)
ln(Sale) (t-1)	0.0140***	-0.0280***	0.0301***	-0.0249***	0.00831	-0.0285***	0.0311***	-0.0186***
	(3.22)	(-5.94)	(10.24)	(-7.41)	(1.47)	(-4.36)	(7.62)	(-4.11)
ROA (t-1)	0.0622	0.0594	0.0931***	0.111***	0.0152	0.102	0.106***	0.147***
	(1.47)	(1.30)	(3.26)	(3.39)	(0.27)	(1.56)	(2.59)	(3.22)
Loss (t-1)	0.0258	0.00296	0.00527	0.0194	-0.0340	0.0162	-0.00512	0.0476
	(0.91)	(0.10)	(0.27)	(0.88)	(-0.87)	(0.36)	(-0.18)	(1.51)
KZ4 (t-1)	-0.00462	0.0211***	-0.000695	0.0136***	-0.00302	0.0346***	0.00466	0.0215***
	(-0.89)	(3.75)	(-0.20)	(3.39)	(-0.46)	(4.51)	(0.97)	(4.04)
LTD (t-1)	0.0617***	-0.0361**	0.00907	-0.0450***	0.0566**	-0.0751***	-0.00902	-0.0832***
	(3.74)	(-2.02)	(0.81)	(-3.53)	(2.47)	(-2.83)	(-0.55)	(-4.52)
Return (t-1)	-0.0300**	-0.0137	-0.0134*	0.0216**	0.000762	0.00152	0.00212	0.0365***
	(-2.51)	(-1.06)	(-1.65)	(2.33)	(0.05)	(0.09)	(0.20)	(3.12)
Return (t)	0.0201*	-0.00148	-0.00299	-0.00526	0.0302**	-0.0125	0.000970	-0.00938
	(1.83)	(-0.12)	(-0.40)	(-0.62)	(2.34)	(-0.84)	(0.10)	(-0.90)
MB (t-1)	0.00908**	0.0191***	0.0307***	0.0382***	0.0110**	0.0143***	0.0320***	0.0339***
	(2.45)	(4.77)	(12.28)	(13.37)	(2.42)	(2.73)	(9.76)	(9.30)
Vol (t-1)	0.0408	0.261***	0.335***	0.439***	0.103**	0.300***	0.386***	0.537***
	(1.12)	(6.60)	(13.52)	(15.54)	(2.04)	(5.14)	(10.59)	(13.25)
IND (t-1)	0.0830***	0.0703***	0.0338***	0.00531	0.0786***	0.104***	0.0294***	0.0167
	(7.20)	(5.63)	(4.34)	(0.60)	(5.39)	(6.18)	(2.79)	(1.43)
Tenure (t-1)	-0.0499***	-0.0282***	-0.0229***	0.00953*	-0.0363***	-0.0212**	-0.0185***	0.0184**
	(-7.09)	(-3.71)	(-4.81)	(1.76)	(-4.05)	(-2.04)	(-2.86)	(2.55)
NCEO (t)	0.0173	-0.0532**	0.0720***	-0.00133	0.0390	-0.0209	0.0806***	0.0269
	(0.83)	(-2.36)	(5.12)	(-0.08)	(1.53)	(-0.71)	(4.38)	(1.31)
Dual (t-1)	0.0131	0.00486	0.0138*	-0.0152*	-0.000423	0.000390	0.00814	-0.0164
	(1.19)	(0.41)	(1.87)	(-1.79)	(-0.03)	(0.02)	(0.79)	(-1.42)
Constant	0.341***	0.803***	-0.202***	0.416***	0.228**	0.700***	-0.323***	0.224***
	(4.84)	(10.53)	(-4.24)	(7.65)	(2.37)	(6.43)	(-4.75)	(2.96)
Year FE	Y		Y		Y		Y	
Industry FE	Y		Y		Y		Y	
N	6496		6496		3323		3323	
R-sq	0.075	0.133	0.208	0.330	0.082	0.158	0.230	0.374

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 2.5: CEO and directors pay-for-performance compensation and determinants of compensation structure: Non-financial firms

(Continued from the previous page)

This table reports the coefficient estimates from seemingly unrelated regressions (SUR) in a sample of 6496 (or 3323 with DIRBLK) non-financial firm years. In model (1) and (3), the dependent variables are CEO_p and BRD_p, which are indicators for the firm years awarding stock option grants to the CEO and outside directors, respectively. In model (2) and (4), the dependent variables are CEO_r and BRD_r, which refer to (the value of stock options granted to the CEO/total compensation for CEO) and (the value of stock options granted to outside directors/total compensation for outside directors), respectively. The independent variables include R&D_4yr=1 if the firm has continuously recognized R&D expenditure for the past 4 years, 0 otherwise; DIRBLK=1 if a blockholder (who owns more than 5% of the outstanding common shares) sits on the board as an outside director, 0 otherwise; Segments= the number of business segments; and ln(Sale)= the natural logarithm of sales. The details about other control variables are available in Table 2.1. Independent variables, except for NCEO, are lagged by one year. All specifications include the year dummy and the industry dummy variables (created by Fama-Frech 48 industrial classification code). The standard errors computed in SUR is robust for correlation between equations. In parentheses, t-statistics are reported.

Table 2.6: CEO and directors pay-for-performance compensation and determinants of compensation structure: Financial firms

	(1)		(2)		(3)		(4)	
	CEO_p	BRD_p	CEO_r	BRD_r	CEO_p	BRD_p	CEO_r	BRD_r
Bank	0.0507	-0.0820*	0.0316	-0.0458	0.0228	-0.164***	0.0406	-0.0573
	(1.57)	(-1.95)	(1.48)	(-1.64)	(0.58)	(-2.92)	(1.30)	(-1.50)
DIRBLK					0.0121	-0.213***	0.00553	-0.0519
					(0.23)	(-2.85)	(0.13)	(-1.02)
ln(Sale) (t-1)	0.0194**	-0.0278***	0.0288***	-0.0289***	0.00825	-0.0544***	0.0286***	-0.0384***
	(2.38)	(-2.63)	(5.35)	(-4.12)	(0.75)	(-3.45)	(3.27)	(-3.58)
ROA (t-1)	-0.844***	0.0913	-0.456**	0.452*	-0.630	-0.490	-0.639*	-0.133
	(-2.97)	(0.25)	(-2.43)	(1.84)	(-1.31)	(-0.71)	(-1.68)	(-0.28)
Loss (t-1)	-0.137	0.0323	-0.0687	-0.103	0.0528	0.0276	-0.119	-0.113
	(-1.35)	(0.25)	(-1.03)	(-1.18)	(0.31)	(0.11)	(-0.89)	(-0.69)
KZ4 (t-1)	-0.0418**	0.00839	-0.0269**	0.00649	-0.0295	0.0119	-0.0382**	-0.0213
	(-2.48)	(0.38)	(-2.42)	(0.45)	(-1.39)	(0.39)	(-2.27)	(-1.03)
LTD (t-1)	-0.0197	-0.173***	-0.00725	-0.116***	-0.0550	-0.212***	0.0108	-0.138**
	(-0.41)	(-2.76)	(-0.23)	(-2.80)	(-0.97)	(-2.61)	(0.24)	(-2.50)
Return (t-1)	0.0481	0.0532	0.0540**	0.102***	0.0344	0.105	0.0677*	0.161***
	(1.19)	(1.01)	(2.03)	(2.94)	(0.69)	(1.48)	(1.71)	(3.32)
Return (t)	0.0681*	0.0497	0.00942	0.0262	0.0774*	0.0733	0.0228	0.0500
	(1.89)	(1.06)	(0.40)	(0.84)	(1.88)	(1.25)	(0.70)	(1.25)
MB (t-1)	-0.0313**	0.0186	0.00253	0.0293**	-0.0484**	0.0247	-0.00786	0.0264
	(-2.17)	(0.99)	(0.27)	(2.36)	(-2.48)	(0.89)	(-0.51)	(1.39)
Vol (t-1)	-0.128	0.573***	0.324***	0.679***	-0.210	0.834***	0.410***	0.924***
	(-1.34)	(4.63)	(5.16)	(8.28)	(-1.51)	(4.20)	(3.72)	(6.84)
IND (t-1)	0.0618**	-0.000135	0.0599***	-0.0345	0.0385	0.0521	0.0535*	0.0110
	(2.03)	(-0.00)	(2.98)	(-1.32)	(1.11)	(1.05)	(1.95)	(0.33)
Tenure (t-1)	-0.0226	-0.00882	-0.00200	0.0233	-0.0195	-0.0555*	0.0165	0.00440
	(-1.32)	(-0.40)	(-0.18)	(1.58)	(-0.95)	(-1.91)	(1.02)	(0.22)
NCEO(t)	0.0290	-0.0948	0.0479	-0.000456	-0.0563	-0.162*	0.0358	-0.0382
	(0.54)	(-1.35)	(1.34)	(-0.01)	(-0.86)	(-1.73)	(0.69)	(-0.60)
Dual (t-1)	0.0628**	-0.00133	0.0404**	-0.0339	0.0738**	0.0484	0.0577**	0.00453
	(2.25)	(-0.04)	(2.20)	(-1.41)	(2.18)	(1.00)	(2.15)	(0.14)
_cons	0.701***	0.714***	-0.0692	0.382***	0.820***	0.943***	-0.137	0.421***
	(6.91)	(5.41)	(-1.03)	(4.37)	(6.48)	(5.22)	(-1.36)	(3.42)
Year FE	Y		Y		Y		Y	
N	1003		1003		509		509	
R-sq	0.094	0.104	0.169	0.220	0.105	0.177	0.117	0.255

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 2.6: CEO and directors pay-for-performance compensation and determinants of compensation structure: Financial firms

(Continued from the previous page)

This table reports the coefficient estimates from seemingly unrelated regressions (SUR) for financial firms. The analyses reported in panel A consider both non-financial and financial firms while in panel B, only financial firms are considered. In model (1) and (3) of both panels, the dependent variables are CEO_p and BRD_p, which are indicators for the firm years awarding stock option grants to the CEO and outside directors, respectively. In model (2) and (4), the dependent variables are CEO_r and BRD_r, which refer to (the value of stock options granted to the CEO/total compensation for CEO) and (the value of stock options granted to outside directors/total compensation for outside directors), respectively. The independent variables include Bank=1 if Fama-French 48 industrial code is 44, 0 otherwise; DIRBLK=1 if a blockholder (who owns more than 5% of the outstanding common shares) sits on the board as an outside director, 0 otherwise; and ln(Sale)= the natural logarithm of sales. To fully exploit the observations, DIRBLK is considered only in model (3) and (4) of each panel. The details about other control variables are available in Table 2.1. Independent variables are lagged by one year. All specifications include the year dummy and the industry dummy variables (created by Fama-Frech 48 industrial classification code). The standard errors computed in SUR is robust for correlation between equations. In parentheses, t-statistics are reported.

Table 2.7: CEO-directors joint compensation structure: Non-financial firms

Panel A: All firms

	CEOBRD_r				CEOBRD_p				CEOBRD_indr			
	LL	LH	HL	HH	LL	LH	HL	HH	LL	LH	HL	HH
R&D_4yr (t-1)	-0.0412**	-0.00547	0.0420	0.00474	-0.0276***	-0.0142	0.0568**	-0.0150	-0.0780***	-0.0270	0.0560*	0.0490
	(-2.15)	(-0.30)	(1.36)	(0.11)	(-2.61)	(-1.22)	(2.14)	(-0.47)	(-3.02)	(-1.47)	(1.79)	(1.05)
Segments (t-1)	0.0177**	-0.00142	0.00999	-0.0263**	0.00382	0.00399	0.00800	-0.0158	0.0212*	-0.0118	0.00856	-0.0180
	(2.04)	(-0.17)	(1.15)	(-2.34)	(0.63)	(0.60)	(1.00)	(-1.63)	(1.67)	(-1.30)	(0.90)	(-1.54)
ln(sales) (t-1)	-0.0166*	-0.0325***	0.0479***	0.00122	-0.0000288	-0.0150**	0.0259***	-0.0108	-0.0115	-0.0361***	0.0425***	0.00512
	(-1.65)	(-4.76)	(6.12)	(0.10)	(-0.01)	(-2.47)	(3.21)	(-0.92)	(-1.19)	(-5.05)	(5.37)	(0.47)
Controls	Y				Y				Y			
Year FE	Y				Y				Y			
Industry FE	Y				Y				Y			
N	6496				6496				6496			

Panel B: Firms with DIRBLK

	CEOBRD_r				CEOBRD_p				CEOBRD_indr			
	LL	LH	HL	HH	LL	LH	HL	HH	LL	LH	HL	HH
R&D_4yr (t-1)	-0.0699**	0.0195	0.0457	0.00477	-0.0189	-0.00323	0.0657*	-0.0436	-0.0965***	-0.0143	0.0732**	0.0377
	(-2.30)	(0.78)	(1.22)	(0.13)	(-1.39)	(-0.17)	(1.90)	(-1.35)	(-2.87)	(-0.48)	(2.06)	(0.97)
DIRBLK (t-1)	0.00667	0.0354	0.0802***	-0.122***	0.00663	0.0182	0.0505	-0.0754*	-0.00447	0.0176	0.0437	-0.0569**
	(0.32)	(1.36)	(3.21)	(-4.28)	(0.53)	(0.93)	(1.17)	(-1.72)	(-0.16)	(0.58)	(1.57)	(-2.07)
Segments (t-1)	0.00315	-0.0113	0.0141	-0.00595	-0.00950**	-0.00519	0.0183**	-0.00361	-0.00300	-0.00990	0.0189**	-0.00603
	(0.29)	(-1.48)	(1.55)	(-0.53)	(-2.33)	(-0.71)	(1.96)	(-0.30)	(-0.22)	(-1.16)	(2.19)	(-0.54)
ln(sales) (t-1)	-0.0217**	-0.0298***	0.0520***	-0.000493	-0.00603	-0.00450	0.0324***	-0.0219*	-0.0286***	-0.0318***	0.0513***	0.00904
	(-1.98)	(-2.88)	(5.23)	(-0.04)	(-1.53)	(-0.54)	(3.56)	(-1.89)	(-2.72)	(-2.92)	(4.52)	(0.74)
Controls	Y				Y				Y			
Year FE	Y				Y				Y			
Industry FE	Y				Y				Y			
N	3323				3323				3323			

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 2.7: CEO-directors joint compensation structure: Non-financial firms

(Continued from the previous page)

Each panel of this table presents the average partial effect estimates of three multinomial logit regressions for non-financial firms. Panels A and B report the results from the extended sample period (i.e., 1996–2005 without directors' blockholding ownership) and from the shorter sample period (i.e., 1996–2001 but including directors' blockholding ownership), respectively. To highlight the economic significance, this table presents values for the average partial effects, not the standard multinomial logit coefficients. In each panel, dependent variables are categorical compensation variables: *CEOBRD_r* in the first four columns, *CEOBRD_p* in the next four columns, and *CEOBRD_indr* in the last four columns. All independent variables reported in Table 2.5 are considered but this table presents only partial effects of *R&D_4yr*, *DIRBLK*, *Segments* and *ln(Sales)*. The details about dependent and independent variables are available in Table 2.1. All specifications include one-year lagged independent variables and also control for the year dummy and the industry dummy variables (created by the Fama-Frech 48 industrial classification code). The standard errors are adjusted for clustering at the industry level. In parentheses, t-statistics are reported.

Table 2.8: CEO-directors joint compensation structure: Financial firms

Panel A: All firms

	CEOBRD_r				CEOBRD_p				CEOBRD_indr			
	LL	LH	HL	HH	LL	LH	HL	HH	LL	LH	HL	HH
Bank	0.0212	-0.0374**	0.0517	-0.0355**	-0.0479**	-0.00400	0.129***	-0.0767	-0.0477*	0.0382	-0.0287	0.0381
	(0.36)	(-2.51)	(1.26)	(-2.08)	(-2.27)	(-0.21)	(2.90)	(-1.46)	(-1.68)	(0.84)	(-0.94)	(1.09)
ln(sales) (t-1)	0.000811	-0.0473**	0.0504***	-0.00390	-0.00554	-0.0146*	0.0339***	-0.0138***	-0.00363	-0.0346***	0.0306*	0.00759
	(0.04)	(-2.33)	(4.26)	(-0.31)	(-0.48)	(-1.66)	(25.86)	(-4.02)	(-1.06)	(-3.52)	(1.93)	(0.70)
Controls		Y				Y				Y		
Year FE		Y				Y				Y		
N		1003				1003				1003		

Panel B: Firms with DIRBLK

	CEOBRD_r				CEOBRD_p				CEOBRD_indr			
	LL	LH	HL	HH	LL	LH	HL	HH	LL	LH	HL	HH
Bank	0.0652	-0.0961**	-0.00772	0.0386	-0.000988	-0.0285	0.170***	-0.141**	-0.0166	0.00794	-0.0882	0.0968*
	(1.10)	(-2.52)	(-0.13)	(0.75)	(-0.03)	(-1.12)	(2.79)	(-2.30)	(-0.29)	(0.17)	(-1.59)	(1.75)
DIRBLK (t-1)	-0.198**	0.0803*	0.203***	-0.0856	-0.0113	0.0172	0.213***	-0.218***	-0.0376	0.0465	0.146**	-0.155*
	(-2.39)	(1.73)	(2.90)	(-1.11)	(-0.28)	(0.46)	(3.19)	(-2.73)	(-0.53)	(0.80)	(2.32)	(-1.82)
ln(sales) (t-1)	-0.00969	-0.0443***	0.0662***	-0.0122	0.00363	-0.0121	0.0508***	-0.0423***	0.00776	-0.0603***	0.0485***	0.00402
	(-0.65)	(-3.54)	(4.33)	(-0.83)	(0.44)	(-1.34)	(3.36)	(-2.61)	(0.54)	(-4.25)	(3.47)	(0.26)
Controls		Y				Y				Y		
Year FE		Y				Y				Y		
N		509				509				509		

***,**, and *: significance at the 1, 5, and 10 percent level, respectively.

Table 2.8: CEO-directors joint compensation structure: Financial firms

(Continued from the previous page)

Each panel of this table presents the average partial effect estimates of three multinomial logit regressions for financial firms. Panels A and B report the results from the extended sample period (i.e., 1996–2005 without directors' blockholding ownership) and from the shorter sample period (i.e., 1996–2001 but including directors' blockholding ownership), respectively. To highlight the economic significance, this table presents values for the average partial effects, not the standard multinomial logit coefficients. In each panel, dependent variables are categorical compensation variables: *CEOBRD_r* in the first four columns, *CEOBRD_p* in the next four columns, and *CEOBRD_indr* in the last four columns. All independent variables reported in Table 2.6 are considered but this table presents only partial effects of *Bank*, *DIRBLK*, and *ln(Sales)*. The details about dependent and independent variables are available in Table 2.1. All specifications include one-year lagged independent variables and also control for the year dummy. The standard errors are adjusted for clustering at the industry level in Panel A but not in panel B since the number of observations is not sufficient. In parentheses, t-statistics are reported.

Appendices

Appendix A

Proof of Propositions and Lemmas (Chapter 1)

Proof of Lemma 1.3.1: The first order condition of maximizing $(\frac{1}{3}+e+\Delta)w_u+(\frac{1}{3}-2\Delta)w_m+(\frac{1}{3}-e+\Delta)w_d-\frac{1}{2}\gamma_m e^2$ with respect to e is

$$w_u - w_d - \gamma_m e = 0,$$

which proves the lemma.

Proof of Proposition 1.3.2: It is trivial that $w_m^* = w_d^* = 0$. The first order condition with respect to w_u is

$$\frac{r^u - r^d}{\gamma_m} - \frac{1}{3} - \frac{2w_u^*}{\gamma_m} = 0, \tag{A.1}$$

which proves the proposition.

Proof of Lemma 1.3.3: The managerial effort choice in (1.7) is proved in lemma 1.3.1. The managerial risk-choice is also immediate from maximizing $(\frac{1}{3}+e+\Delta)w_u+(\frac{1}{3}-2\Delta)w_m+(\frac{1}{3}-e+\Delta)w_d-\frac{1}{2}\gamma_m e^2$ with respect to Δ.

Proof of Proposition 1.3.4: To facilitate the notation, I denote the optimal managerial pay when shareholders induce the managerial choice of Δ_s as $w^s(\tilde{r}) = (w_u^s, w_m^s, w_d^s)$ and the optimal managerial pay when shareholders induce the managerial choice of Δ_0 as $w^0(\tilde{r}) = (w_u^0, w_m^0, w_d^0)$. From lemma 1.3.3, it is obvious that (i) $w_m^s = w_d^s = 0$ and that (ii) $w_m^0 = \frac{w_u^0}{2}$ and $w_d^0 = 0$. Solving the shareholders maximization problem, I find that $w_u^s = \frac{r^u - r^d}{2} - \gamma_m(\frac{1}{6} + \frac{\Delta_s}{2})$ and $w_u^0 = \frac{r^u - r^d}{2} - \frac{\gamma_m}{4}$. To find the optimal managerial compensation, I compare the shareholders' indirect utility functions by plugging w_u^s and w_u^0 into the shareholder value function in (1.6). Specifically, the shareholders' indirect utility function when $\Delta^* = \Delta_s$ is

$$V^s = \frac{1}{3}(r^u + r^m + r^d) + \frac{w_u^s}{\gamma_m}(r^u - r^d) - (\frac{1}{3} + \frac{w_u^s}{\gamma_m + \Delta_s})w_0^s \tag{A.2}$$

while the indirect utility function when $\Delta^* = \Delta_0$ is

$$V^0 = \frac{1}{3}(r^u + r^m + r^d) + \frac{w_u^0}{\gamma_m}(r^u - r^d) - (\frac{1}{2} + \frac{w_u^0}{\gamma_m})w_u^0 \tag{A.3}$$

Therefore, $V^s - V^0 = (\frac{1}{12} - \frac{\Delta_s}{2})(r^u - r^d - \gamma_m(\frac{5}{12} + \frac{\Delta_s}{2}))$. Note that $V^s > V^0$ if $w_u^0 > 0$. Thus, shareholders induce the managerial choice of Δ_s by offering $w^s(\tilde{r})$.

Proof of Proposition 1.3.5: This is immediate from Proposition 1.3.2 and Proposition 1.3.4.

Appendix B

Proof of Propositions and Lemmas (Chapter 2)

Proof of Lemma 2.3.1: This is straightforward since the zero board compensation induces the board to truthfully report the manager's choice of Δ and to remain uninformed about θ.

Proof of Lemma 2.3.2: The first order condition of maximizing $V_m(\hat{\theta}_m, e; \theta_i, w_m^{'})$ with respect to e is

$$\theta_i(u_m(\hat{\theta}_m) - d_m(\hat{\theta}_m) - \gamma_m e = 0,$$

which proves the lemma.

Proof of Proposition 2.3.3: Since zero compensation induces the board to truthfully reports to shareholders about the message received from the manager $\hat{\theta}_m$ and to produce truthful evidence of the manager's choice of Δ, this case is equivalent to the case in which shareholders directly communicate and contract with the manager by observing the manager's choice of Δ but not the productivity θ. In what follows, I first show that the optimal managerial compensation contract features a pooling contract with respect to $\hat{\theta}_m$ and then characterize the optimal contractual arrangements. For simplicity, I define $\sigma_m^j \equiv w_m^{'}(\theta_j^m) = (u_m^j, m_m^j, d_m^j)$ for $j = h, l$. Suppose that $\sigma_m^h \neq \sigma_m^l$. Since shareholders observe the manager's choice of Δ, they can require the manager to make a certain choice of $\Delta^j \in \{\Delta_0, \Delta_s\}$ when the manager reports to shareholders θ_m^j. Without loss of generality, I consider the case in which $u_m^h - d_m^h > u_m^l - d_m^l$ (i.e., shareholders induce higher managerial effort when the manager reports θ_h^m) and shareholders require $\Delta^h = \Delta_0$. Lemma 2.3.2 suggests that for $\theta = \theta_i$ $(i = h, l)$, the manager who reports θ_j^m selects the effort level as $e_{i,j} = \frac{\theta_i(u_m^j - d_m^j)}{\gamma_m}$. Thus, when the manager observes $\theta = \theta_l$, his expected utility from reporting θ_m^h is

$$V_m^{l,h} = \frac{1}{3}(u_m^h + m_m^h + d_m^h) + \frac{\theta_l^2(u_m^h - d_m^h)^2}{2\gamma_m} \tag{B.1}$$

and, thus, the manager truthfully reports θ_l^m if and only if

$$V_m^{l,l} = \frac{1}{3}(u_m^l + m_m^l + d_m^l) + \frac{\theta_l^2(u_m^l - d_m^l)^2}{2\gamma_m} + \Delta^l(u_m^l + d_m^l - 2m_m^l) \geq V_m^{l,h} \tag{B.2}$$

Note that (B.2) is binding. When shareholders offer the manager a menu of separating contracts, shareholder value can be written as:

$$\begin{aligned} V_s^{sep} = V_0 &+ \frac{\theta_h^2(u_m^h - d_m^h)}{\gamma_m} p(r^u - r^d) + \frac{\theta_l^2(u_m^l - d_m^l)}{\gamma_m}(1-p)(r^u - r^d) \\ &- p\left[\frac{1}{3}(u_m^h + m_m^h + d_m^h) + \frac{\theta_h^2(u_m^h - d_m^h)^2}{\gamma_m}\right] \\ &- (1-p)\left[\frac{1}{3}(u_m^l + m_m^l + d_m^l) + \frac{\theta_l^2(u_m^l - d_m^l)^2}{\gamma_m} + \Delta^l(u_m^l + d_m^l - 2m_m^l)\right] \end{aligned} \tag{B.3}$$

Alternately, by offering a pooling contract $\{u_m^h, m_m^h, d_m^h\}$, shareholders obtain the expected pay-off:

$$
\begin{aligned}
V_s^h = V_0 &+ \frac{\theta_h^2(u_m^h - d_m^h)}{\gamma_m} p(r^u - r^d) + \frac{\theta_l^2(u_m^h - d_m^h)}{\gamma_m}(1-p)(r^u - r^d) \\
&- p\left[\frac{1}{3}(u_m^h + m_m^h + d_m^h) + \frac{\theta_h^2(u_m^h - d_m^h)^2}{\gamma_m}\right] \\
&- (1-p)\left[\frac{1}{3}(u_m^h + m_m^h + d_m^h) + \frac{\theta_l^2(u_m^h - d_m^h)^2}{\gamma_m}\right]
\end{aligned} \tag{B.4}
$$

Since (B.2) is binding, (B.4) can be rewritten as

$$
\begin{aligned}
V_s^h = V_0 &+ \frac{\theta_h^2(u_m^h - d_m^h)}{\gamma_m} p(r^u - r^d) + \frac{\theta_l^2(u_m^h - d_m^h)}{\gamma_m}(1-p)(r^u - r^d) \\
&- p\left[\frac{1}{3}(u_m^h + m_m^h + d_m^h) + \frac{\theta_h^2(u_m^h - d_m^h)^2}{\gamma_m}\right] \\
&- (1-p)\left[\frac{1}{3}(u_m^h + m_m^h + d_m^h) + \frac{\theta_l^2(u_m^l - d_m^l)^2}{2\gamma_m} + \Delta^l(u_m^l + d_m^l - 2m_m^l)\right] \\
&- (1-p)\frac{\theta_l^2(u_m^h - d_m^h)^2}{2\gamma_m}
\end{aligned} \tag{B.5}
$$

By subtracting (B.3) from (B.5),

$$
V_s^h - V_s^{sep} = \frac{(1-p)(\lambda^h - \lambda^l)}{\gamma_m}\left[(r^u - r^d) - \frac{\lambda^h + \lambda^l}{2}\right], \tag{B.6}
$$

where $\lambda^h = \theta_l^2(u_m^h - d_m^h)$ and $\lambda^l = \theta_l^2(u_m^l - d_m^l)$

Shareholders never offer a compensation such that $\lambda^h > r^u - r^d$. Since $\lambda^h > \lambda^l$, $V_s^h > V_s^{sep}$, which implies that shareholders would rather offer $\{u_m^h, m_m^h, d_m^h\}$ as a pooling contract than offer a menu of separating contracts. To find the optimal pooling contract, I solve for the managerial compensation $\{u_m^h, m_m^h, d_m^h\}$ that maximizes (B.4). Obviously, $m_m^h = d_m^h = 0$. The first order condition with respect to u_m^h is

$$\frac{(p\theta_h^2 + (1-p)\theta_l^2)(r^u - r^d)}{\gamma_m} - \frac{1}{3} - \frac{2(p\theta_h^2 + (1-p)\theta_l^2)u_m^h}{\gamma_m} = 0, \tag{B.7}$$

which proves the proposition.

Proof of Lemma 2.4.1: The lemma is proved by showing that for any board compensation $w_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r})$ that induces the board to truthfully reports its private information about θ, there exists a corresponding board compensation that has a form characterized in the lemma and induces the same board's choices and the associated managerial actions. For an arbitrary truth-telling mechanism $w_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r})$, set $\hat{\Delta}^h \in \{\hat{\Delta}_0, \hat{\Delta}_s\}$ and $\sigma_m^h = w_m(\hat{\Delta}^h)$ (resp. $\hat{\Delta}^l$ and $\sigma_m^l = w_m(\hat{\Delta}^l)$) are the board's choices of $\hat{\Delta}$ and σ_m when the board reports θ_h^b (reps. θ_l^b). Consider an alternative board compensation contract $w_b^{'}(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r})$ such that

$$w_b^{'}(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}) = \begin{cases} w_b(\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}) & \text{if } (\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}) = (\theta_h^b, \hat{\Delta}^h, \sigma_m^h, \tilde{r}) \\ & \text{or } (\hat{\theta}_b, \hat{\Delta}, \sigma_m, \tilde{r}) = (\theta_l^b, \hat{\Delta}^l, \sigma_m^l, \tilde{r}) \\ (0,0,0) & \text{otherwise.} \end{cases}$$

Then, the informed board's optimal choices induced by $w_b^{'}$ and the associated managerial choices equal to the corresponding choices induced by w_b. The uninformed board's expected compensation from $w_b^{'}$ is lower than that from w_b and, thus, $w_b^{'}$ satisfies the board's monitoring incentive compatibility constraints. This proves the lemma.

Proof of Lemma 2.4.2 and Lemma 2.4.6: omitted since they are similar to the proof of lemma 2.4.1.

Proof of Proposition 2.4.3 and Proposition 2.4.7: omitted since they are fully discussed in the text.

Proof of Proposition 2.4.5 and Proposition 2.4.9: refer to the proof of lemma 2.3.2

Proof of Proposition 2.4.10: To prove proposition 2.4.10, I first prove the following lemma which characterizes the optimal form of managerial compensation:

Lemma B.0.1. *In the informed board case, the optimal managerial compensation features either* $\sigma_m^j = (u_m^j, 0, 0)$ *or* $(u_m^j, \frac{u_m^j}{2}, 0)$ *for* $j = h, l$.

Proof of Lemma B.0.1: Consider a case in which shareholders induce the informed board to offer the manager $\sigma_m^j = \{u_m^j, m_m^j, d_m^j\}$ such that $u_m^j + d_m^j > 2m_m^j$ and $m_m^j, d_m^j > 0$ when they receive the board's message θ_j^b $(j = h, l)$. As implied by propositions 2.4.5 and 2.4.9, when the manager observes $\theta = \theta_i$ $(i = h, l)$, σ_m^j induces managerial effort $e^{i,j} = \frac{\theta_i(u_m^j - d_m^j)}{\gamma_m}$. Corollaries 2.4.4 and 2.4.8 also imply that given σ_m^j as above, the manager chooses Δ_0 if and only if shareholders induce the board to report $\hat{\Delta}^j = \hat{\Delta}_0$ and award board compensation such that $C_b^j = u_b^j + d_b^j - 2m_b^j \leq 0$. Now consider an alternative managerial compensation contract $\sigma_m^{j'} = \{u_m^j - d_m^j, 0, 0\}$. It is apparent that the managerial actions (e, Δ) induced by $\sigma_m^{j'}$ equals the managerial actions induced by σ_m^j. Therefore, the board compensation contracts that replace σ_m^j with $\sigma_m^{j'}$ also satisfies the board's monitoring incentive compatibility constraints while it reduces the expected value of managerial compensation. Hence, shareholders would induce the board to offer the manager $\sigma_m^{j'}$ rather than σ_m^j. Similarly, the managerial compensation plan such that $u_m^j + d_m^j < 2m_m^j$ and/or $d_m^j > 0$ is dominated by an alternative compensation plan $\{u_m^j, \frac{u_m^j}{2}, 0\}$.

Next, I prove the following lemma which characterizes the optimal form of board compensation:

Lemma B.0.2. *The optimal board compensation features that* $\sigma_b^h = (u_b^h, 0, 0)$ *or* $(u_b^h, \frac{u_b^h}{2}, 0)$ *and* $\sigma_b^l = (f_b^l, f_b^l, f_b^l)$.

Proof of Lemma B.0.2: Without loss of generality, I focus on the case in which $u_m^h \geq u_m^l$ since otherwise shareholder do not induce the board to monitor θ. I first show that w_b^l should be a fixed wage. Suppose that $u_b^l > d_b^l$. Then, since $\theta_h \geq \theta_l$, $V_b^{h,l}(w_b) > V_b^{l,l}(w_b)$, where $V_b^{i,j}(w_b)$ is the informed board's expected compensation when the board observes $\theta = \theta_i$ and reports θ_j^b $(i, j \in \{h, l\})$. Now suppose that shareholders alternately offer the board a fixed wage $\sigma_b^l = \{f_b^l, f_b^l, f_b^l\}$ such that $f_b^l = V_b^{l,l}(w_b)$. Then, when the board observes $\theta = \theta_h$ and falsely reports to shareholders θ_l^b, its expected compensation also corresponds to f_b^l. Since $V_b^{h,l}(w_b) > f_b^l$, constraint (2.22) does not change while (2.23) is relaxed. Therefore, shareholders can reduce the expected value of the compensation awarded to the board who reports θ_h^b. Next, I show that $\sigma_b^h = (u_b^h, 0, 0)$ or $(u_b^h, \frac{u_b^h}{2}, 0)$. For the board compensation $\sigma_b^h = \{u_b^h, m_b^h, d_b^h\}$ such that $d_b^h > 0$, let us consider an alternative plan $\sigma_b^{h'} = \{u_b^h + k_1 d_b^h, m_b^h, 0\}$, where $k_1 = \frac{\frac{1}{3} - \frac{\theta_h^2 u_m^h}{\gamma_m} + \Delta^h}{\frac{1}{3} + \frac{\theta_h^2 u_m^h}{\gamma_m} + \Delta^h}$. If shareholders replace w_b^h with $\sigma_b^{h'}$, (2.22) is relaxed while (2.23) does not change and, thus, shareholders can obtain higher expected pay-off. Now suppose that $m_b^h > \frac{u_b^h}{2}$ and the board induces $\Delta^h = \Delta_0$. Then, shareholders can offer $\sigma_b^{h'} = \{u_b^h + k_2\epsilon, \frac{u_b^h + k_2\epsilon}{2}, 0\}$, where $k_2 = \frac{\frac{1}{3}}{\frac{1}{3} + \frac{\theta_h^2 u_m^h}{\gamma_m}}$ and $\epsilon = \frac{2m_b^h - u_b^h}{2 + k_2}$. Then, (2.22) is relaxed while (2.23) does not change and, thus, shareholders can obtain higher expected pay-off. Similarly, if the board induces $\Delta^h = \Delta_0$ and $m_b^h > 0$, shareholders can obtain higher expected pay-off by offering $w_b^{h'} = \{u_b^h + k_3 m_b^h, 0, 0\}$, where $k_3 = \frac{\frac{1}{3} - 2\Delta_s}{\frac{1}{3} + \frac{\theta_h^2 u_m^h}{\gamma_m} + \Delta_s}$.

By lemmas B.0.1 and B.0.2, I can prove proposition 2.4.10 by showing that (i) $\sigma_m^l = (u_m^l, 0, 0)$ and (ii) the optimal compensation structure can feature either $\sigma_m^h = (u_m^h, \frac{u_m^h}{2}, 0)$ or $\sigma_b^h = (u_b^h, \frac{u_b^h}{2}, 0)$ but not both. First, corollary 2.4.4 implies that the fixed board wage $\sigma_b^l = (f_b^l, f_b^l, f_b^l)$ provides the board with incentives to induce the managerial choice Δ_0 by truthfully reporting to shareholders about the managerial choice of Δ. Therefore, the optimal compensation structure features $\sigma_m^l = (u_m^l, 0, 0)$ which induces the managerial effort most efficiently. Next, corollary 2.4.4 also implies that to induce the managerial choice of Δ_s when the board reports θ_h^b, either $C_m^h = 0$ or $C_b^h = 0$. If $\sigma_m^h = (u_m^h, \frac{u_m^h}{2}, 0)$ (i.e., $C_m^h = 0$) and induces the managerial choice of Δ_0, the optimal board compensation features $\sigma_b^h = (u_b^h, 0, 0)$ which induces the board's monitoring on θ most efficiently. On the other hand, $\sigma_b^h = (u_b^h, \frac{u_b^h}{2}, 0)$ (i.e., $C_b^h = 0$) which provides the board's incentives to induce the managerial choice of Δ_0, the optimal managerial compensation features $\sigma_m^h = (u_m^h, 0, 0)$ which induces the managerial effort most efficiently.

Proof of Proposition 2.4.12: Since (2.26) and (2.25) are binding at the optimal compensation, u_b^h and f_l^b of the optimal compensation structure correspond to

$$u_b^h = \frac{\gamma_b \gamma_m}{p(1-p)(\theta_h^2 - \theta_l^2)u_m^h} \tag{B.8}$$

$$f_b^l = \begin{cases} (\frac{1}{3} + \Delta_s + \frac{\theta_l^2 u_m^h}{\gamma_m})u_b^h + \frac{\gamma_b}{1-p} & \text{in speculation case} \\ (\frac{1}{2} + \frac{\theta_l^2 u_m^h}{\gamma_m})u_b^h + \frac{\gamma_b}{1-p} & \text{in disciplinary board case} \\ (\frac{1}{3} + \frac{\theta_l^2 u_m^h}{\gamma_m})u_b^h + \frac{\gamma_b}{1-p} & \text{in contracting board case} \end{cases} \tag{B.9}$$

Therefore, by plugging the optimal forms of contracts stated in proposition 2.4.10,(B.8) and (B.9) into shareholders' problems specified in (2.24)-(2.28), I obtain the following first order conditions with respect to u_m^h in each case:

$$\begin{aligned}
\text{SP: } & \frac{p\theta_h^2(r^u - r^d)}{\gamma_m} - p\left[\left(\frac{1}{3} + \Delta_s\right) + \frac{2\theta_h^2 u_{m,sp}^h}{\gamma_m}\right] \\
& + \left(\frac{1}{3} + \Delta_s\right)\frac{\gamma_b\gamma_m}{p(1-p)(\theta_h^2 - \theta_l^2)(u_{m,sp}^h)^2} = 0 \qquad \text{(B.10)}
\end{aligned}$$

$$\text{DB: } \frac{p\theta_h^2(r^u - r^d)}{\gamma_m} - p\left[\frac{1}{3} + \frac{2\theta_h^2 u_{m,db}^h}{\gamma_m}\right] + \frac{\gamma_b\gamma_m}{2p(1-p)(\theta_h^2 - \theta_l^2){u_{m,db}^h}^2} = 0 \qquad \text{(B.11)}$$

$$\text{CB: } \frac{p\theta_h^2(r^u - r^d)}{\gamma_m} - p\left[\frac{1}{2} + \frac{2\theta_h^2 u_{m,cb}^h}{\gamma_m}\right] + \frac{\gamma_b\gamma_m}{3p(1-p)(\theta_h^2 - \theta_l^2){u_{m,cb}^h}^2} = 0 \qquad \text{(B.12)}$$

and the first order condition with respect to u_m^l implies that the optimal compensation features $u_m^l = \frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}$

Proof of Proposition 2.4.13: $u_{m,db}^h > u_{m,sp}^h > u_{m,cb}^h$ is immediate from (B.10), (B.11), and (B.12). $u_{m,db}^l = u_{m,sp}^l = u_{m,cb}^l$ is demonstrated in proposition 2.4.12. $u_{b,cb}^h > u_{b,sp}^h > u_{b,db}^h$ is immediate from the relation $u_{m,db}^h > u_{m,sp}^h > u_{m,cb}^h$ and (B.8). Finally, $f_{b,db}^l > f_{b,sp}^l > f_{b,cb}^l$ is obtained from (B.9) and the first order conditions, (B.10), (B.11), and (B.12).

Proof of Proposition 2.5.1: Shareholder values specified in (2.29)-(2.32) imply that:

1. Δ_s: Higher Δ_s decreases shareholder value only in speculation case.

Thus, higher Δ_s either decreases shareholders value in informed board cases relative to the uninformed board case (when speculation case is the optimal among informed board cases) or does not affect shareholders value (when speculation case is not optimal)

2. γ_b: Higher γ_b decreases shareholder value in all three informed board cases while it does not affect shareholder value in uninformed board case

3. D_θ: Higher D_θ increases shareholder value in all three informed board cases while it does not affect shareholder value in uninformed board case

4. $r^u - r^d$: By envelop theorem, the shadow price of $r^u - r^d$ in each case is as follows:

$$\text{Uninformed board case: } \frac{V_\theta}{\gamma_m}\left(\frac{r^u - r^d}{2} - \frac{\gamma_m}{6V_\theta}\right)$$
$$\text{Speculation case: } \frac{p\theta_h^2 u_{m,s}^h + (1-p)\theta_l^2 u_{m,s}^l}{\gamma_m}$$
$$\text{Disciplinary board case: } \frac{p\theta_h^2 u_{m,d}^h + (1-p)\theta_l^2 u_{m,d}^l}{\gamma_m}$$
$$\text{Contracting board case: } \frac{p\theta_h^2 u_{m,c}^h + (1-p)\theta_l^2 u_{m,c}^l}{\gamma_m}$$

The first order conditions (B.10)-(B.12) imply that $u_{m,d}^h > u_{m,s}^h > u_{m,c}^h > \frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_h^2}$ and proposition 2.4.12 states that $u_{m,d}^l = u_{m,s}^l = u_{m,c}^l = \frac{r^u - r^d}{2} - \frac{\gamma_m}{6\theta_l^2}$. Thus, the shadow price of $r^u - r^d$ in the three informed board cases is higher than that in uninformed board case. This implies that higher Δ_s increases shareholders value in informed board cases relative to shareholder value in uninformed board case.

Proof of Proposition 2.5.2: This is immediate from (2.30)-(2.32) which show that Δ_s does not affect shareholder value in disciplinary board and contracting board cases while it decreases shareholder value in speculation case.

Proof of Proposition 2.5.3:

1. γ_b: By envelop theorem, the shadow price of γ_b in each case is as follows:

$$\begin{aligned}
&\text{Speculation case: } -\left(\frac{1}{3}+\Delta_s\right)\frac{2}{D_\theta u_{m,s}^h}-\left(\frac{V_\theta}{\gamma_m D_\theta}+1\right)\\
&\text{Disciplinary board case: } -\frac{1}{D_\theta u_{m,d}^h}-\left(\frac{V_\theta}{\gamma_m D_\theta}+1\right)\\
&\text{Contracting board case: } -\frac{2}{3D_\theta u_{m,c}^h}-\left(\frac{V_\theta}{\gamma_m D_\theta}+1\right)
\end{aligned}$$

As demonstrated in (2.30)-(2.32), shareholder value in disciplinary board case is larger than those in other informed board cases if

$$-\frac{\gamma_b}{D_\theta u_{m,d}^h}+\frac{p\theta_h^2 {u_{m,d}^h}^2}{\gamma_m} \geq -\left(\frac{1}{3}+\Delta_s\right)\frac{2\gamma_b}{D_\theta u_{m,s}^h}+\frac{p\theta_h^2 {u_{m,s}^h}^2}{\gamma_m} \tag{B.13}$$

and

$$-\frac{\gamma_b}{D_\theta u_{m,d}^h}+\frac{p\theta_h^2 {u_{m,d}^h}^2}{\gamma_m} \geq -\frac{2\gamma_b}{3D_\theta u_{m,c}^h}+\frac{p\theta_h^2 {u_{m,c}^h}^2}{\gamma_m} \tag{B.14}$$

As stated in proposition 2.4.13, $u_{m,d}^h > u_{m,s}^h > u_{m,c}^h$ and therefore when shareholders obtain the same value in all three cases,

$$\frac{1}{D_\theta u_{m,d}^h} > \left(\frac{1}{3}+\Delta_s\right)\frac{2}{D_\theta u_{m,s}^h} > \frac{2}{3D_\theta u_{m,c}^h}.$$

This implies that higher γ_b decreases shareholders value most in disciplinary board case. Thus, the optimal compensation is more likely to belong to disciplinary board case as γ_b decreases. Thus, the result is proved.

2. D_θ: omitted since it is very similar to the proof relative to γ_b.

3. $r_u - r_d$: By envelop theorem, the shadow price of $r_u - r_d$ in each regime is as follows.

$$\text{Speculation case: } \frac{p\theta_h^2 u_{m,s}^h + (1-p)\theta_l^2 u_m^l}{\gamma_m}$$
$$\text{Disciplinary board case: } \frac{p\theta_h^2 u_{m,d}^h + (1-p)\theta_l^2 u_m^l}{\gamma_m}$$
$$\text{Contracting board case: } \frac{p\theta_h^2 u_{m,c}^h + (1-p)\theta_l^2 u_m^l}{\gamma_m}$$

Since $u_{m,d}^h > u_{m,s}^h > u_{m,c}^h$ and $u_{m,d}^l = u_{m,s}^l = u_{m,c}^l$, higher $r_u - r_d$ increases shareholder value in disciplinary board case relative to other cases.

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